MAGNETIC INSTRUMENTATION • SEMICONDUCTORS • SENSORS

F.W. BELL

Subsidiary, Magnetics & Electronics, Inc.

LEADERS IN:

INSTRUMENTS
TRANSDUCERS
MAGNETIZERS
HALL GENERATORS
CURRENT MEASURING EQUIPMENT

F.W. BELL

SALES BULLETIN

Subject: F. W. BELL, INC. WARRANTY **No.** 136

F. W. BELL, INC. warrants each instrument of its manufacture to be free from defects in material and workmanship. Our obligation under this warranty is limited to servicing or adjusting any instrument returned to our factory for that purpose, and to replacing any defective parts thereof. This warranty covers instruments which within one year after the shipping date to the original purchaser, shall be returned with transporation charge prepaid by the original purchaser, and which upon examination shall disclose to our satisfaction to be defective. If it is determined that the defect has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost after submitting an estimate to the purchaser.

F. W. BELL, INC. reserves the right to make changes in design at any time without incurring any obligation to install same on unit previously purchased.

This warranty is expressly in lieu of all other obligations or liabilities on the part of F. W. BELL, INC., and F. W. BELL, INC. neither assumes nor authorizes any other person to assume for them any other liability in connection with the sales of F. W. BELL, INC. instruments.

DAMAGES IN SHIPMENT

The instrument should be examined and tested as soon as it is received. If it does not operate properly, or is damaged in any way, immediately file a claim with the carrier. The claim agent will provide report forms. A copy of the completed form should be forwarded to us. We will then make the necessary arrangements for repair or replacement. All correspondence concerning this instrument should include model and serial numbers.

SHIPPING INSTRUCTIONS

All shipments of F. W. BELL, INC. instruments should be made via United Parcel Service (UPS) or Air Freight. Always use the original shipping carton and inserts, if possible, or pack the instrument in a sturdy container and surround the entire instrument with two or three inches of shock-absorbing material.

OCTOBER 1977

6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

Digitized by the Internet Archive
in 2025

https://archive.org/details/manualsplus_06743

Majestic Industries Inc.
Teterboro, N. J.

F. W. Bell Short Form Catalog

- Current-Sensing/Measuring
- Magnetic Instrumentation
- Transducers

F. W. BELL CURRENT GUN™ PROBE

DESCRIPTION

The Model CG-100A Current Gun Probe lets you measure currents from dc to 1 kHz and from 0 to 200 amps accurately, quickly and safely on your voltmeter or scope.

No need to break the circuit or disturb insulation. Merely squeeze the trigger and slip the probe over any conductor up to ¾-inch in diameter. This Hall effect device is the end result of technology developed and perfected over the years by F. W. Bell and proven in the 1776 Current Meter.

SPECIFICATIONS

ACCURACY:	2.0% of FS:
RANGES:	±10 A (dc or Peak ac) ±100 A (dc or Peak ac) 100% overrange capability*
OUTPUT:	±1 V/10 A ±1 V/100 A
FREQUENCY RESPONSE:	dc to 1.0 kHz operable to 5.0 kHz*
OUTPUT IMPEDANCE:	approximately 125 Ω
RECOMMENDED LOAD:	≥100 kΩ
OPERATING TEMPERATURE RANGE:	−10°C to +65°C
BATTERY LIFE: (4 AA SIZE REQUIRED)	Mercury—60 hours continuous Alkaline—30 hours continuous Nicad—8 hours continuous
PROBE ISOLATION CAPABILITY:	600 V dc or Peak ac
APERTURE SIZE:	0.75″ (19 mm) diameter
WEIGHT:	approximately 2 lbs. (0.9 kg)

*with slightly reduced accuracy

ORDERING INFORMATION

Contact F. W. Bell, Inc. for application assistance. Product assistance and technical literature are availale.

Model 1776

DESCRIPTION

The Bell model 1776 digital current meter provides accurate measurement of ac, dc and ac-on-dc current with non-contact, clamp-on probes. It is not necessary to break the circuit to make a current measurement. This time-saving feature is extremely helpful in the troubleshooting, MRO and design fields. Now it's possible to obtain current measurements more easily and safely than voltage measurements, with complete isolation from the bus.

The Bell model 1776 digital current meter introduces virtually no resistance on dc readings and extremely small impedance on ac readings. In this way, measurements can be made with a minimum of disturbance in the measured circuit.

The unique circuit design, coupled with the digital readout, provides a wide dynamic range of measurements with excellent resolution. Peak read and hold capability is standard. This function permits you to read and hold the reading of the peak current appearing on the measured conductor. The 1776 is designed for portable operation with internal rechargeable batteries and for 115/230 Vac, 50-60 Hz line operation.

SPECIFICATIONS

Current Ranges (with applicable probe)	**1000 amperes. F.S.** **100 amperes. F.S.** **10 amperes. F.S.**
Accuracy	
dc	**±1.0%. F.S.**
ac (Sinusoidal)	**±1.0%. F.S.**
Peak Detection (dc accuracy)	**±2.0%. F.S.**
Frequency Response	**dc to 5 kHz**
Power Requirements	**115/230 Vac 50/60Hz and internal rechargeable Nicad batteries, with built-in trickle charge circuitry.**

PROBES

There are three standard probes available for the 1776 digital current meter, and other probes can be designed and supplied to meet special requirements.

Each standard probe is designed for a distinct full scale range. These are 1000, 100 and 10 A. The probes are self-calibrating and are interchangeable on any 1776 current meter.

SPECIAL PROBES

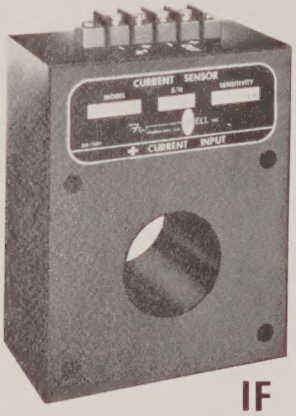
An example of a special probe designed and manufactured by Bell. Probe has 4.1-inch jaws, as compared to 11/32- and 4.1-inch jaws on standard probes. F. W. Bell will be pleased to quote on probes to meet your specific needs upon receipt of specifications.

ORDERING INFORMATION

Contact F. W. Bell, Inc. for application assistance. Product assistance and technical literature are available. If standard models are not suitable, F. W. Bell, Inc. can design one for your special electrical and physical requirements.

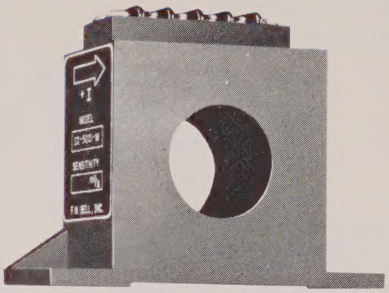
FEATURES

- Fast-responding
- Non-contact operation
- Output voltage isolated from input
- Very low insertion impedance
- Minimal distortion from adjacent conductors
- Amplified and non-amplified models available

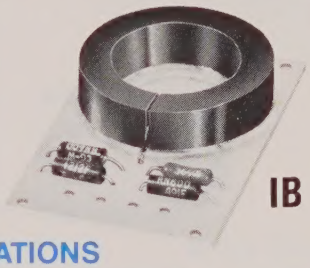


IF

IA



ID



IB

DESCRIPTION

Bell Current Sensors are small, lightweight, inexpensive devices for non-contact current measurements to 3000 A dc or peak ac up to 1 kHz.

The sensors are non-contact, Hall-effect devices, offering no dc insertion loss, power loss, isolation or heating problems.

The Hall-effect sensor is a four-pole, magneto-sensitive device mounted in the core gap, and reads the magnetic field surrounding the conductor passing through the gap. The field is proportional to the unknown current, and the output voltage of the Hall generator is proportional to this magnetic field, thus proportional to the current.

Various units in the broad line of F. W. Bell current sensors find applications in the automotive, aerospace, industrial and power generation fields. Bell's extensive background may be called upon to assist in solving specific sensing problems, including the design of equipment for your special electrical and/or physical requirements.

TYPICAL APPLICATIONS

- Monitoring and control of dc motor circuits
- Overload sensor in dc power supplies
- Control of dc motor driven machine tools
- Replacements for shunts, particularly in hostile environments, in airborne circuits and when isolation is required
- Monitoring and control of battery load and charge circuits
- Current sensing element in feedback circuits, on interlocks and on dc circuit breakers
- Process control element in dc operated processes
- Power measurement in dc power circuits

ORDERING INFORMATION

Contact F. W. Bell, Inc. for application assistance. Product assistance and technical literature are available. If standard models are not suitable, F. W. Bell, Inc. can design one for your special electrical and physical requirements.

SPECIFICATIONS

model	rated current	rated output	accuracy
ID-5001M	350 A ac/dc	0.5 to 1.1 mV/A	±2% RO
ID-5011M	350 A ac/dc	0.5 mV/A	±2% RO
ID-5021M	350 A ac/dc	0.5 mV/A	±2% RO
ID-5031M	350 A ac/dc	0.5 mV/A	±2% RO
IA-5023P	250 A dc	10 V dc	±0.5% RO
IA-5022P	500 A dc	10 V dc	±0.5% RO
IA-5021P	1000 A dc	10 V dc	±0.5% RO
IA-5020P	2000 A dc	10 V dc	±0.5% RO
IA-5024P	3000 A dc	10 V dc	±0.6% RO
IA-5025P	2500 A dc	10 V dc	±0.5% RO
IB-5001B	350 A ac/dc	0.5 to 1.1 mV/A	±2% RO
IB-5011M	350 A ac/dc	0.5 mV/A	±2% RO
IB-5001M42	100 A ac/dc	0.5 to 1.1 mV/A	±2% RO
IB-5011M42	100 A ac/dc	0.5 mV/A	±2% RO
IF-5002M	500 A ac/dc	0.15 to 0.30 mV/A	±0.5% RO
IF-5001M	1000 A ac/dc	0.15 to 0.30 mV/A	±0.5% RO
IF-5000M	2000 A ac/dc	0.15 to 0.30 mV/A	±0.5% RO

HALL EFFECT GAUSSMETERS

DESCRIPTION

Bell Gaussmeters are designed to accurately measure magnetic flux density. Twenty-eight models and 110 standard field probes meet the demanding requirements of most applications.

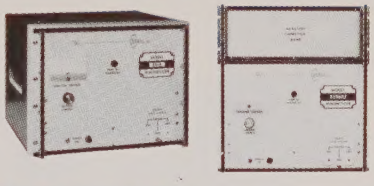
Bell Gaussmeters provide four magnetic field measurement models: direct measurement of absolute magnetic field density, differential measurement of the difference in magnetic field density at two probe locations, incremental field measurements using an expanded scale and summation measurements.

There are 110 standard probe models for each gaussmeter model. Each is a precision, solid-state, magnetic field sensor built into a rugged package for accurate, repeatable, stable, field measurements. Models available for transverse, axial, differential, two-axis, and three-axis measurements with a variety of field ranges, field sensitivities, and configurations for each.

SPECIFICATIONS

Gaussmeter model	ranges FS Gauss	accuracy	dc output voltage FS
811 digital	10 to 100,000	±0.1% FS	1 Volt
810 field monitor	10 to 100,000	±0.1% FS	1 Volt
660 digital	1 to 100,000	±0.1% to 10 kG ±0.3% to 30 kG	1 Volt
640 incremental	0.1 to 30,000	±0.25% FS	1 Volt 5 Volts
620 precalibrated	0.1 to 30,000	±0.25% FS	1 Volt
615 digital	10 to 100,000	±0.5% FS	100 mV BCD
610 self-calibrated	1 to 100,000	±0.5% FS	100 mV
600 general purpose	100 to 30,000	±4% FS	1 Volt

MAGNETIZERS



DESCRIPTION

Bell magnetizers are capacitive discharge power units designed to supply current pulses to a magnetizing fixture coil. The energy level of the pulse is variable and accurately repeatable.

Bell fixtures are designed to apply the proper pulsed magnetic field to the magnet or magnet assembly. The fixtures provide the field shape and direction to accommodate the specific magnet configuration and magnetization direction. Special fixtures that simulate specific magnetic circuits are available. F. W. Bell supplies fixture design assistance.

FEATURES

- **FULLY SOLID-STATE**

The entirely solid-state units are designed for long life and high reliability.

- **LOW VOLTAGE MAGNETIZER**

The magnetizer operates at high capacity and low voltage for personal safety and long equipment life.

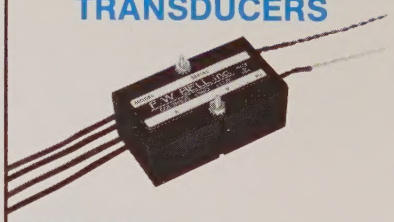
- **MANUAL OR AUTOMATIC OPERATION**

Magnetizer and stabilizer units are usually manually operated, but they may be integrated into automatic systems through the use of optional equipment.

SPECIFICATIONS

model number	energy maximum watt-sec	storage voltage, Volts
860	600	35 to 350
861		
860 A	1200	
861 A		
870	1800	
871		
870 A	3000	
871 A		

REAL POWER TRANSDUCERS



DESCRIPTION

PX 2000 and PX 4000 series transducers are compact, accurate, and dependable solid-state modules for the measurement and control of single-phase and three-phase power in various frequency ranges. The module output is a power-proportional dc voltage.

The light-weight transducers are epoxied in small nylon cases with through mounting holes and wire leads. This configuration facilitates assembly with associated devices. Simplicity, versatility, high performance, and low cost make these modules ideal for many applications.

SPECIFICATIONS

	PX 2000 series	PX 4000 series
Rated power levels	50-2000 W	1000-2000 W
Rated current levels	0.5-20 A	5 A
Rated voltage	120 V 220 V	220 V
Frequencies, nominal	60-180-360 Hz	1-3 kHz
Frequency range	25 to 1200 Hz	0.5 to 10 kHz
Rated dc output across 50 ohm	± 55 mV	≥ 27 mV
Ripple, peak to peak	<200%	<200%
Response time to 99%	<50μs	<5μs
Rated accuracy	0.5%	0.5%
Linearity vs. power	± 0.2%	± 0.2%

ORDERING INFORMATION

Contact F. W. Bell, Inc. for application assistance. Product assistance and technical literature are available. If standard models are not suitable, F. W. Bell, Inc. can design one for your special electrical and physical requirements.

Subsidiary,
Magnetics & Electronics, Inc.

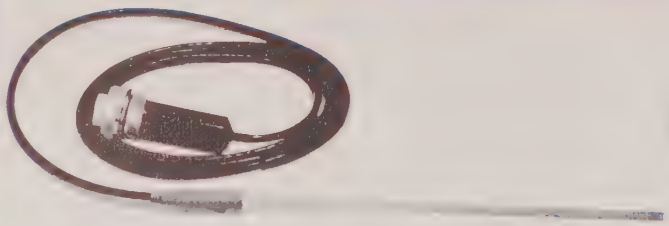
BELL INC.®

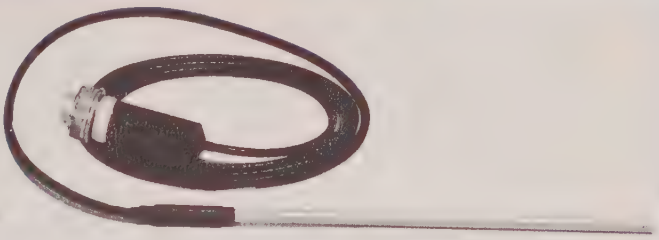
6120 Hanging Moss Road • Orlando, Florida 32807
TWX: 810-853-3115 • Phone: (305) 678-6900

Majestic Industries Inc.
Teterboro, N J

GAUSSMETER PROBES

THIRD GENERATION





DESCRIPTION

The third generation of Bell gaussmeter probes is comprised of a wide range of probe models designed to meet the electrical and mechanical requirements of virtually any application. The probes are precision, solid state magnetic field sensors built for accurate, repeatable, stable field measurements. Models are available for transverse, axial, two axis, or three axis field measurements with a variety of field measurements ranges, field sensitivities and physical configurations for each. Calibrated extension cables and high sensitivity magnaprobes are also available.

The third generation supercedes and replaces all other Bell gaussmeter probes. The lower price, improved quality, and increased model selection are the benefits of new technology and experience. Individual probe linearity curves are available as an option. CAUTION! Probes are fragile! Handle with care!

MODEL NUMBERING

Each probe model is classified with a three letter, five numeral model number. The chart below shows the significance of each letter and numeral. At the factory the assembled probes are calibrated to match the input characteristics of each gaussmeter model. The model to which the probe is calibrated is indicated by a numeral in the fourth space of the model number. A model SAE1-0602 will operate properly with any model 610 gaussmeter. The model SAE6-0602 will only work with a model 660 gaussmeter although it is physically identical to the SAE1-0602. With their proper respective gaussmeters the probe model SAE1-0602 and model SAE6-0602 have the same characteristics. Thus, to simplify the model listing the fourth space has been omitted. Please insert the number which corresponds to the gaussmeter that will be used with the probe. The sensitivity number is the constant by which the meter reading is multiplied to obtain the actual reading.

S A E 1 — 06 02

GAUSSMETER
- 1 – 610/615
- 4 – 620/640
- 0 – ALL TYPES (ext. cables only)
- 6 – 660
- 8 – 800 SERIES

PROBE TYPE
- A – AXIAL
- T – TRANSVERSE
- O – NOT APPLICABLE

PROBE STYLE
- C – CRYOGENIC
- F – FLEXIBLE
- H – HEAVY DUTY
- S – STANDARD
- D – DIFFERENTIAL
- M – MAGNA
- Y – 2 AXIS
- Z – 3 AXIS
- X – EXTENSION CABLE

ELECTRICAL PERFORMANCE

B – 1.0%	10kG	1X
E – 2.0%	10kG	1X
G – 2.0%	30kG	1X
I – 3.0%	10kG	1X
J – 0.1%	10kG	10X
K – 0.25%	10kG	10X
L – 0.25%	30kG	10X
N – 0.5%	30kG	10X
P – 1.0%	30kG	10X
R – 1.0%	100kG	10X
U – 2.0%	100kG	10X
W – 2.5%	2G	.01X

- Q – CALIBRATED
- V – UNCALIBRATED

OD OR THICKNESS

AXIAL OD
- 06 – .060 IN.
- 08 – .080 IN.
- 09 – .090 IN.
- 12 – .120 IN.
- 18 – .180 IN.
- 25 – .250 IN.
- 32 – .320 IN.

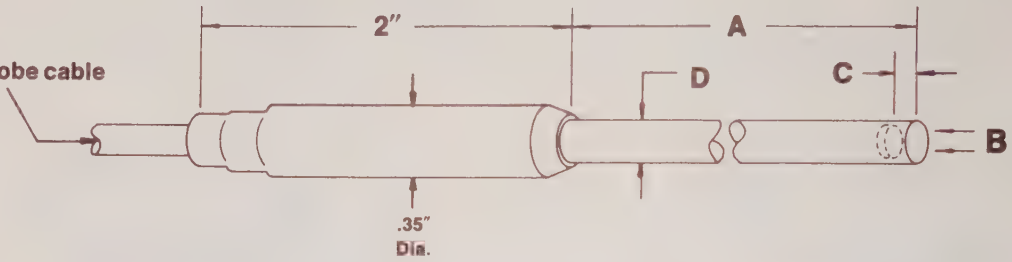
THICKNESS
- 00 – .010 IN.
- 01 – .015 IN.
- 02 – .020 IN.
- 03 – .030 IN.
- 04 – .040 IN.
- 06 – .060 IN.
- 25 – .250 IN.

PROBE LENGTH
- 02 – 2 IN.
- 04 – 4 IN.
- 06 – 6 IN.
- 08 – 8 IN.
- 15 – 15 IN.
- 18 – 18 IN.
- 36 – 36 IN.
- 48 – 48 IN.
- 60 – 60 IN.

EXTENSION CABLE LENGTH
- 0010 – 10 FT.
- 0025 – 25 FT.
- 0050 – 50 FT.
- 0100 – 100 FT.

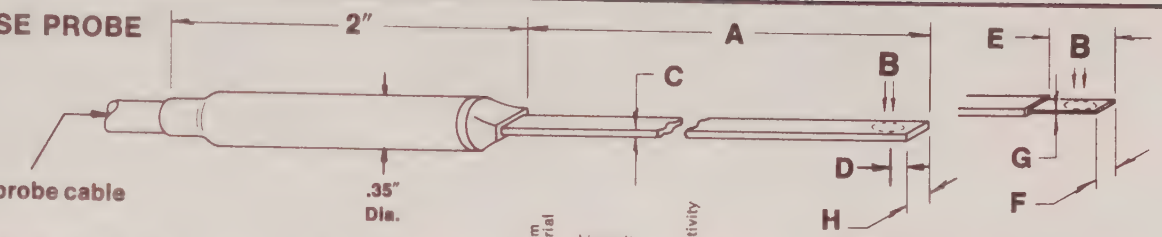
AXIAL PROBE

Includes 5 foot probe cable



Model	Price	A	D	C	Stem Material	Linearity % of Reading	Sensitivity	Active Area	Operating Temperature Range	Temperature Zero	Stability (max.) Calibrate
SAE— -0602	$536	2″±.063	.060″ +.001 —.003	.005″ ±.002	Aluminum	2% to 10 kG	1x blue	.020″ dia. nom.	0°C to +75°C	±.20 Gauss /°C	—.08% /°C
SAE— -0608	551	8″±.125									
SAE— -0618	567	18″±.125									
SAE— -0802	467	2″±.063	.080″ ±.003								
SAE— -0808	483	8″±.125									
SAE— -0818	494	18″±.125									
SAE— -0836	520	36″±.25									
SAB— -1202	362	2″±.063	.120″ +.000 —.005			1% to 10 kG		.030″ dia. nom.		±.13 Gauss /°C	±.005% /°C
SAB— -1208	378	8″±.125									
SAB— -1218	394	18″±.125									
SAB— -1236	415	36″±.25									
SAK— -1802	289	2″±.063	.180″ +.002 —.004	.010″ ±.002		.25% to 10 kG	10x red				
SAK— -1808	305	8″±.125									
SAK— -1818	310	18″±.125									
SAK— -1836	341	36″±.25									
SAN— -1802	357	2″±.063				.5% to 30 kG					
SAN— -1808	368	8″±.125									
SAN— -1818	383	18″±.125									
SAN— -1836	410	36″±.25									
SAR— -1802	425	2″±.063				1% to 100 kG					
SAR— -1808	441	8″±.125									
SAR— -1818	452	18″±.125									
SAR— -1836	483	36″±.25									
SAB— -1802	152	2″±.063				1% to 10 kG	1x blue			±.09 Gauss /°C	—.04% /°C
SAB— -1808	168	8″±.125									
SAB— -1818	184	18″±.125									
SAB— -1836	210	36″±.25									
SAG— -1802	194	2″±.063				2% to 30 kG					
SAG— -1808	210	8″±.125									
SAG— -1818	221	18″±.125									
SAG— -1836	257	36″±.25									
HAK— -2502	299	2″±.063	.250″ ±.005			.25% to 10 kG	10x red				
HAK— -2508	310	8″±.125									
HAK— -2518	326	18″±.125									
HAK— -2536	357	36″±.25									
HAN— -2502	368	2″±.063				.5% to 30 kG				±.13 Gauss /°C	±.005% /°C
HAN— -2508	383	8″±.125									
HAN— -2518	399	18″±.125									
HAN— -2536	425	36″±.25									
HAR— -2502	441	2″±.063				1% to 100 kG					
HAR— -2508	452	8″±.125									
HAR— -2518	467	18″±.125									
HAR— -2536	494	36″±.25									
HAB— -2502	168	2″±.063				1% to 10 kG	1x blue			±.09 Gauss /°C	—.04% /°C
HAB— -2508	184	8″±.125									
HAB— -2518	194	18″±.125									
HAB— -2536	221	36″±.25									
HAG— -2502	210	2″±.063				2% to 30 kG					
HAG— -2508	221	8″±.125									
HAG— -2518	236	18″±.125									
HAG— -2536	263	36″±.25									
CAP— -2548	obsolete	48″±.25		.025″ ±.005	Glass Epoxy	1% to 30 kG	10x red		—269°C to +75°C	±.013 Gauss /°C	±.01% /°C
CAP— -2560	698	60″±.5									
CAU— -2548	obsolete	48″±.25				2% to 100 kG					
CAU— -2560	767	60″±.5									

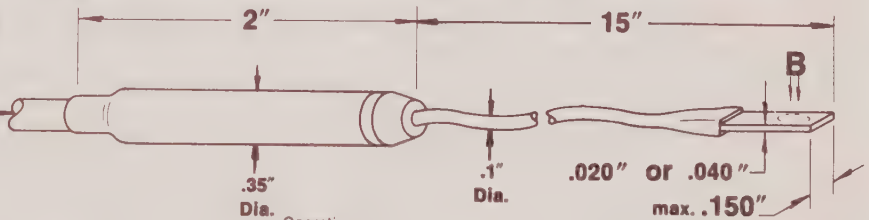
TRANSVERSE PROBE



Includes 5 foot probe cable

Model	Price	A	H	C	D	E	F	G	Stem Material	Linearity % of Reading	Sensitivity	Active Area	Operating Temperature Range	Temperature Stability (max.) Zero	Temperature Stability (max.) Calibrate
STB— -0402	$142	2" ± .063	.150" ±.004	.040" +.000 −.004	.145" ±.063	Not Applicable	Not Applicable	Not Applicable	Rigid Glass Epoxy	1% to 10 kG	1x blue	.070" dia nom.	0°C to +75°C	±.09 Gauss /°C	−.04 %/°C
STB -0404	14	4" ± .063								2% to 30 kG					
STG -0402	168	2" ± .063								.1% to 10 kG	10x red	.040" dia. nom.		±.13 Gauss /°C	±.005 %/°C
STG -0404	173	4" ± .063								.25% to 30 kG					
STJ -0402	257	2" ± .063								1% to 100 kG					
STJ -0404	263	4" ± .063													
STL -0402	326	2" ± .063													
STL -0404	336	4" ± .063													
STR— -0402	399	2" ± .063													
STR— -0404	404	4" ± .063													
HTB— -0608	152	8" ± .125	.180" ±.003	.060" +.000 −.004					Aluminum	1% to 10 kG	1x blue	.070" dia. nom		±.09 Gauss /°C	−.04 %/°C
HTB— -0618	168	18" ± .125								2% to 30 kG					
HTG -0608	184	8" ± .125								.1% to 10 kG	10x red	.040" dia. nom.		±.13 Gauss /°C	±.005 %/°C
HTG— -0618	194	18" ± .125								.25% to 30 kG					
HTJ -0608	273	8" ± .125								1% to 100 kG					
HTJ— -0618	289	18" ± .125													
HTL— -0608	341	8" ± .125													
HTL— -0618	357	18" ± .125													
HTR— -0608	410	8" ± .125													
HTR -0618	425	18" ± .125													
CTP— -3248	obslt	48" ± .25	.312" ±.005 dia.	Not Applicable	.320" ±.063				Stainless Steel	1% to 30 kG			−269°C to +75°C		±.01 %/°C
CTP -3260	698	60" ± .5								2% to 100 kG					
CTU— -3248	obslt	48" ± .25													
CTU -3260	767	60" ± .5													
STB -0204	152	4" ± .063	.155" + .005	.040" + .002 .009	.130" ±.008	.375" ± .063	.130" ± .003	.020" ± .003	Semi-rigid	1% to 10 kG	1x blue	.070" dia. nom.	0°C to +75°C	±.09 Gauss/°C	−.04 %/°C
STG -0204	184									1% to 10 kG	10x red	.040 dia. nom.		±.13 Gauss/°C	±.005 %/°C
STJ -0204	273									25% to 30 kG					
STL -0204	341									1% to 100 kG					
STR -0204	410									2% to 10 kG	1x blue			±.15 Gauss/°C	−.08%/°C
STE— -0104	357				055" ± 005	312" ± .031	.080" ± 003	.015" + 000— 003		3% to 10 kG		030" dia. nom.	0°C to +50°C	±.20 Gauss/°C	−.10%/°C
STI— -0004	536				050" ±.005	.375" ± 063	.135" ± 005	010" + 000—.003							

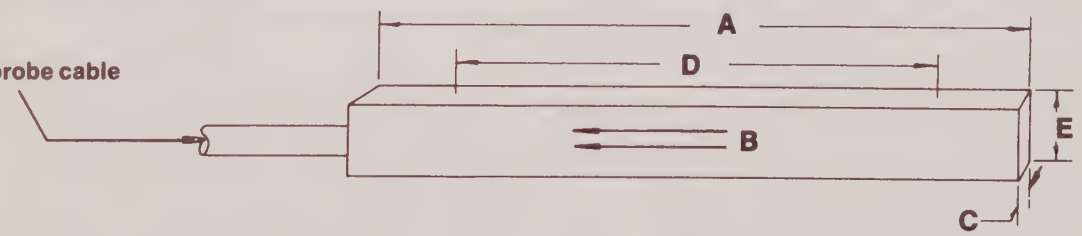
TRANSVERSE FLEXIBLE PROBE



Includes 5 foot probe cable

Model	Price	Linearity % of Reading	Sensitivity	Active Area	Operating Temperature Range	Stem Material	Temperature Stability (max.) Zero	Temperature Stability (max.) Calibrate
FTB— -0415	$173	1% to 10 kG	1x blue	.070" dia. nom.	0°C to +75°C	Flexible Stem Encapsulated Device	±.09 Gauss /°C	—.04% /°C
FTG— -0415	205	2% to 30 kG						
FTJ— -0415	294	.1% to 10 kG	10x red	.040" dia. nom.			±.13 Gauss /°C	±.005% /°C
FTL— -0415	362	.25% to 30 kG						
FTR— -0415	431	1% to 100 kG						
FTB -0215	189	1% to 10 kG	1x blue	.070" dia. nom.		Flexible Stem Exposed Device	±.09 Gauss /°C	—.04% /°C
FTG -0215	215	2% to 30 kG						
FTJ— -0215	305	.1% to 10 kG	10x red	.040" dia. nom.			±.13 Gauss /°C	±.005% /°C
FTL— -0215	378	.25% to 30 kG						
FTR -0215	446	1% to 100 kG						

MAGNAPROBE



Includes 5 foot probe cable

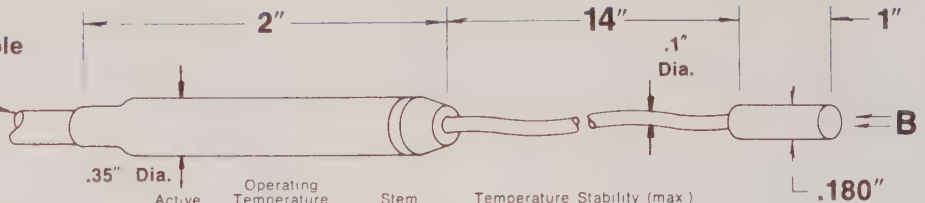
Model	Price	A	E	C	D	Linearity % of Reading	Sensitivity	Active Area	Operating Temperature Range	Temperature Stability (max.) Zero	Temperature Stability (max.) Calibrate
MOW -2506	$326	9" ±.010	.5" ±.015	.25" ±.010	6"	2.5% to 2 G	.01x	6" x .25" nom.	0°C to +75°C	±.001 G/°C	−.05%/°C

THIRD GENERATION

GAUSSMETER PROBES

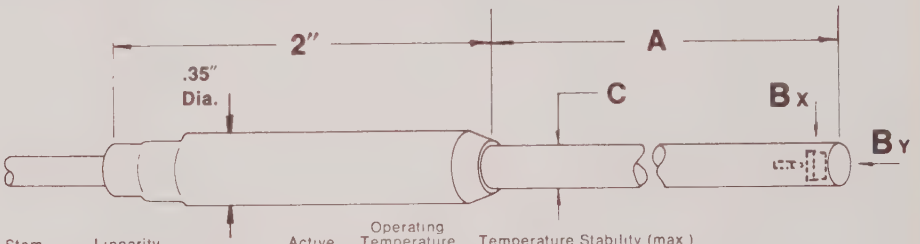
AXIAL FLEXIBLE PROBE

Includes 5 foot probe cable



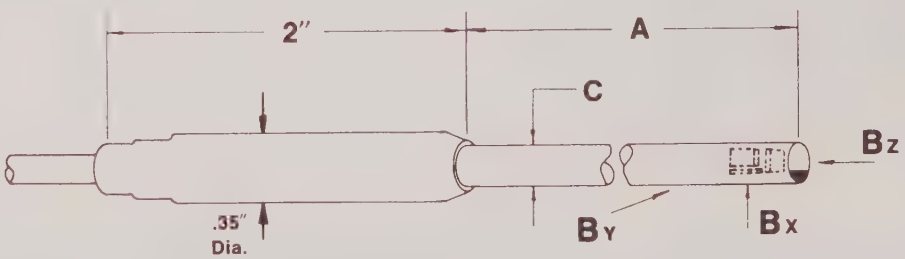
Model	Price	Linearity % of Reading	Sensitivity	Active Area	Operating Temperature Range	Stem Material	Temperature Stability (max) Zero	Temperature Stability (max) Calibrate
FAB -0915	$399	1% to 10 kG	1x blue	.030 dia nom	0°C to +75°C	Flexible Stem	±.13 Gauss/°C	—.08%/°C
FAB -1815	205					Flexible Stem Aluminum Tip .180" x 1"	±.09 Gauss /°C	.04% /°C
FAG -1815	231	2% to 30 kG						
FAK -1815	320	.25% to 10 kG	10x red				±.13 Gauss /°C	— 005% / C
FAN -1815	394	.5% to 30 kG						
FAR -1815	457	1% to 100 kG						

TWO AXIS PROBE



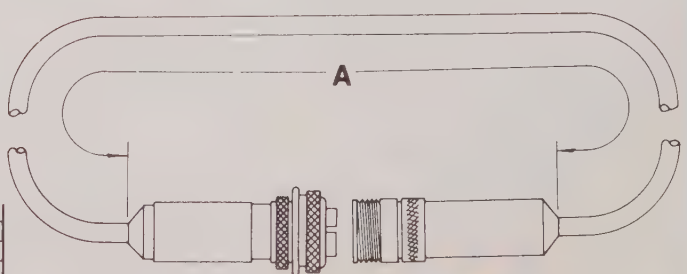
Model	Price	A	C	Stem Material	Linearity % of Reading	Sensitivity	Active Area	Operating Temperature Range	Temperature Stability (max) Zero	Temperature Stability (max) Calibrate
YOB -1802	$609	2" ± .063	.180" +.002 −.004	Aluminum	1% to 10 kG	1x blue	.020 dia Nom.	0°C to +75°C	±.1 Gauss /°C	—.04% /°C
YOB -1808	620	8" ± .125								
YOB -1818	635	18" ± .125								
YOB -1836	667	36" ± .25								

THREE AXIS PROBE



Model	Price	A	C	Stem Material	Linearity % of Reading	Sensitivity	Active Area	Operating Temperature Range	Temperature Stability (max.) Zero	Temperature Stability (max.) Calibrate
ZOB- -3202	$1024	2" ± .063	.312" ± .005	Aluminum	1% to 10 kG	1x blue	.060" dia. nom	0°C to +75°C	±.10 Gauss /°C	—.04% /°C
ZOB- -3208	1040	8" ± .125								
ZOB -3218	1045	18" ± .125								
ZOB -3236	1045	36" ± .25								

EXTENSION CABLES



● **The calibrated extension cables are trimmed at the factory to achieve zero error with a specific probe. The cable will be in calibration with that probe only. Other probes, even of the same model number, will not necessarily be in calibration with the cable.**

Model	Price	A	Error	
XOVO -0010	$ 42	10' ± 2"	1%	
XOQ— -0010	74	10' ± 2"	0.0	●
XOVO -0025	63	25' ± 2"	2%	
XOQ— -0025	95	25' ± 2"	0.0	●
XOVO -0050	95	50' ± 2"	3%	
XOQ— -0050	126	50' ± 2"	0.0	●
XOVO -0100	158	100' ± 2"	5%	
XOQ— -0100	189	100' ± 2"	0.0	●

Specifications subject to change without notice.

Printed in U.S.A.

Subsidiary,
Magnetics & Electronics, Inc.

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

GAUSSMETER PRICE LIST

GAUSSMETERS

model 813 Magnet Sorter	$2130
model 813A Magnet Sorter	2400
model 813R Magnet Sorter	2340
model 813AR Magnet Sorter	2600
model 811 Digital Gaussmeter	2060
model 811A Digital Gaussmeter	2285
model 811B Digital Gaussmeter	2175
model 811R Digital Gaussmeter	2260
model 811AB Digital Gaussmeter	2400
model 811AR Digital Gaussmeter	2485
model 810 Field Monitor	1610
model 810H Field Monitor	1665
model 810R Field Monitor	1690
model 810R2 Field Monitor	2890
model 810R3 Field Monitor	4090
model 810HR Field Monitor	1745
model 810HR2 Field Monitor	2945
model 810HR3 Field Monitor	4145
model 660 Gaussmeter	2795
model 660R Gaussmeter	2870
model 640 Gaussmeter	1735
model 640N Gaussmeter	1785
model 640R Gaussmeter	1860
model 640NR Gaussmeter	1860
model 620 Gaussmeter	1240
model 620D Gaussmeter	1280
model 620N Gaussmeter	1290
model 620R Gaussmeter	1315
model 620Z Gaussmeter	1280
model 620DN Gaussmeter	1335
model 620DR Gaussmeter	1365
model 620DZ Gaussmeter	1325
model 620NR Gaussmeter	1355
model 620NZ Gaussmeter	1335
model 620RZ Gaussmeter	1355
model 620DNR Gaussmeter	1410
model 620DNZ Gaussmeter	1375
model 620DRZ Gaussmeter	1400
model 620NRZ Gaussmeter	1405
model 620DNRZ Gaussmeter	1450
model 615 Digital Gaussmeter	$1180
model 615R Digital Gaussmeter	1255
model 610 Gaussmeter	860
model 610R Gaussmeter	935
model 610Z Gaussmeter	905
model 610RZ Gaussmeter	980
Probes for the gaussmeters listed above are on literature sheet #60700.	
model 600 Gaussmeter (Battery)	385
model 600A Gaussmeter (ac)	450
Listed below are the two standard probes available for the 600/600A:	
STG3-0404 Transverse Probe	121
PAG3-2504 Axial Probe	126
YB-2062 ac Power Supply (For Model 600 Gaussmeter)	84

ACCESSORIES

VA-067A Axial Magnet, 300 g	153
VA-068A Axial Magnet, 100 g	153
VA-070A Transverse Magnet, 300 g	153
VA-071A Transverse Magnet, 1 kg	153
VA-072A Transverse Magnet, 3 kg	153
VB-1839 Transverse Magnet, 10 kg	168
VB-1840 Transverse Magnet, 14 kg	168
YA-111 Zero Gauss Chamber	17
NBS Traceability Certificate	50

TERMS: fob Orlando, FL; net 30 days. Prices do not include applicable taxes, are subject to change without notice, and are for quantities 1-9. Consult the factory for quantity discounts.

Subsidiary,
Magnetics & Electronics, Inc.

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

F.W. BELL INC.

MAGNET SORTER

MODEL 813

FEATURES

- EXCELLENT ACCURACY, 0.2% FS
- HIGH STABILITY
- SIMPLE OPERATION
- RUGGED CONSTRUCTION

APPLICATIONS

Test speaker magnets
PM motor magnets and assemblies
Incoming magnet inspection
Production classification
Quality assurance
Magnetic field sensing or interlocking

DESCRIPTION

F. W. Bell model 813 magnet sorters are **accurate instruments** designed for production classification of magnets and magnet assemblies. The readout consists of good-bad lamps which indicate when the measured magnetic flux density is above, within or below preset ranges. Two and three level sorters are available.

One hundred and ten different magnetic field probes are available to meet the most challenging field measurement requirements. Please see the F. W. Bell *Gaussmeter Probes* literature for probe information and prices.

REVISION APRIL 1975 NUMBER 60681

MODEL 813 MAGNET SORTER

SPECIFICATIONS

field ranges	4 ranges with standard probes; 0-10 Gauss, 0-100 Gauss, 0-1 kG, 0-10 kG 4 ranges with 10X probes; 0-100 Gauss, 0-1 kG, 0-10 kG, 0-100 kG (1 Tesla = 10 kG)
accuracy	
magnetic	± 0.05% of reading plus ± 0.02% of FS plus probe error
set point	±0.2% of FS
calibration	±0.1% traceable to the NBS
set point	
range	0 to the range FS in 1000 increments
stability	±0.1% of FS from –20 °C to +70 °C
indicators	
2 level	2 lamps, "above" and "below"
3 level	3 lamps, "above," "accept" and "below"
output	for all models: a magnetic field analog signal, 0-1 V dc FS; for 813R and 813 AR only: form C relay contacts for each indication, contacts are rated at 2 A rms, 115 Vac, 60 Hz, resistive load
power supply	115/230 V ac, 50/60 Hz
dimensions	bench cabinet, 8½"w x 8½"h x 14"d (21.6cm x 21.6cm x 35.6cm) rack cabinet, 19"w x 7"h x 15"d (48.3cm x 17.8cm x 38.1cm)
weight	bench cabinet, net 16 lb (7.3 kg), shipping 20 lb (9.1 kg) rack cabinet, net 23 lb (10.4 kg), shipping 30 lb (13.6 kg)

PRICES

Please see the F. W. Bell *Instrument Price List* for magnet sorter prices.

MODELS

model	consists of
813	2 level sorter in a bench cabinet
813R	2 level sorter in a rack mount cabinet
813A	3 level sorter in a bench cabinet
813AR	3 level sorter in a rack mount cabinet

PROBES

One hundred and ten different Hall effect field probes are available to meet the challenging requirements of virtually any application. Please see the F. W. Bell *Gaussmeter Probes* literature sheet for probe models and prices. Consult the factory for special probe requirements.

ORDERING INFORMATION

To order, contact your local F. W. Bell, Inc. representative or the main office. Specify the models you require. Application assistance is available for your convenience. Please see the *Hall Effect Gaussmeters and Magnetic Field Probes* literature for a listing of the F. W. Bell Inc. representatives.

specifications subject to change without notice.

FW Subsidiary, Magnetics & Electronics, Inc.
BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

F.W. BELL INC.

MAGNETIC FIELD MONITORS

Models
810
811

FEATURES

- 0.2% ACCURACY TO 100 kG
- INTERNAL CALIBRATION ACCURACY, ±0.1%, TRACEABLE TO THE NBS
- 100 PPM/°C STABILITY
- FREQUENCY RESPONSE TO 400 Hz AT THE OUTPUT JACKS.

DESCRIPTION 810, 811

The model 810 and 811 field monitors are designed specially for applications requiring **high stabilities** with time and temperature and for digital readouts. These two gaussmeters share excellent stability characteristics. Temperature stability is better than 100 ppm/°C from −20 °C to +70 °C. Time stability is better than 0.1% FS maximum for an indefinite period. The model 811 also has a **digital readout** feature.

The model 810 is designed to provide a signal accurately proportional to magnetic flux density. The 810 readout is a 0 to 1 volt signal. This signal may be used for monitoring and control purposes.

The model 811 is designed to provide a digital readout of magnetic flux density. The same components as the 810 make this instrument **accurate and reliable.** The digital panel meter displays magnetic flux density. BCD outputs are standard with the rack mounted model and optional with the bench models. See the reverse of this sheet for individual model descriptions.

One hundred and ten different Hall effect probes adapt the 810 and the 811 to virtually any application. For detailed probe information see the *Third Generation Probes* literature sheet.

Models
810, 811

MAGNETIC FIELD MONITORS

SPECIFICATIONS

field range	4 ranges with standard probes; 0-10 Gauss, 0-100 Gauss, 0-1 kG, 0-10 kG
	4 ranges with 10X probes 0-100 Gauss, 0-1 kG, 0-10 kG, 0-100 kG (1 Tesla = 10 kG)
overranging	2 times with rated accuracy
instrument accuracy	± 0.05% of reading plus ± 0.02% of FS plus probe error
calibration accuracy	±0.1% traceable to the NBS
stability	temperature, 100 ppm/°C −20 °C to + 70 °C
	line voltage, ±0.01% FS 90 V ac to 140 V ac
	time, ±0.1% FS maximum
output	standard; ±1.0 V dc FS, at 0 to 5 mA
	optional; ±10.0 V dc FS
output noise	less than 2 mV rms over entire bandwidth (55 db down from FS)
frequency response	dc to 400 Hz (at output jacks)
power supply	115/230 V ac, 50/60 Hz
dimensions	bench cabinet, 8½" w x 8½" h x 14" d (21.6 cm x 21.6 cm x 35.6 cm)
	rack cabinet, 19" w x 7" h x 15" d (48.3 cm x 17.8 cm x 38.1 cm)
weight	bench cabinet, net 16 lb. (7.3 kg), shipping 20 lb. (9.1 kg)
	rack cabinet, net 23 lb. (10.4 kg), shipping 30 lb. (13.6 kg)

ORDERING INFORMATION

To order, contact your local F. W. Bell, Inc. representative or the main office. Specify the models you require. Application assistance is available for your convenience. Please see the *Hall Effect Gaussmeters and Magnetic Field Probes* literature for a listing of the F. W. Bell Inc. representatives.

MODELS

model	consists of
810	standard field monitor in a bench cabinet
810H	10 V output field monitor in a bench cabinet
810R	standard field monitor in a rack mount cabinet
810R2	2 standard field monitors in a rack mount cabinet
810R3	3 standard field monitors in a rack mount cabinet
810HR	10 V output field monitor in a rack mount cabinet
810HR2	2- 10 V output field monitors in a rack mount cabinet
810HR3	3- 10 V output field monitors in a rack mount cabinet
811	standard digital gaussmeter in a bench cabinet, 3½ digit
811R	standard digital gaussmeter in a rack mount cabinet, 3½ digit
811A	4½ digit gaussmeter in a bench cabinet
811AR	4½ digit gaussmeter in a rack mount cabinet
811B	digital gaussmeter in a bench cabinet, 3½ digit, BCD
811AB	4½ digit gaussmeter in a bench cabinet, BCD

PROBES

One hundred and ten different Hall effect field probes are available to meet the challenging requirements of virtually any application. Please see the F. W. Bell *Gaussmeter Probes* literature sheet for probe models and prices. Consult the factory for special probe requirements.

PRICES

Please see the F. W. Bell *Instrument Price List* for gaussmeter prices.

Subsidiary,
Magnetics & Electronics, Inc

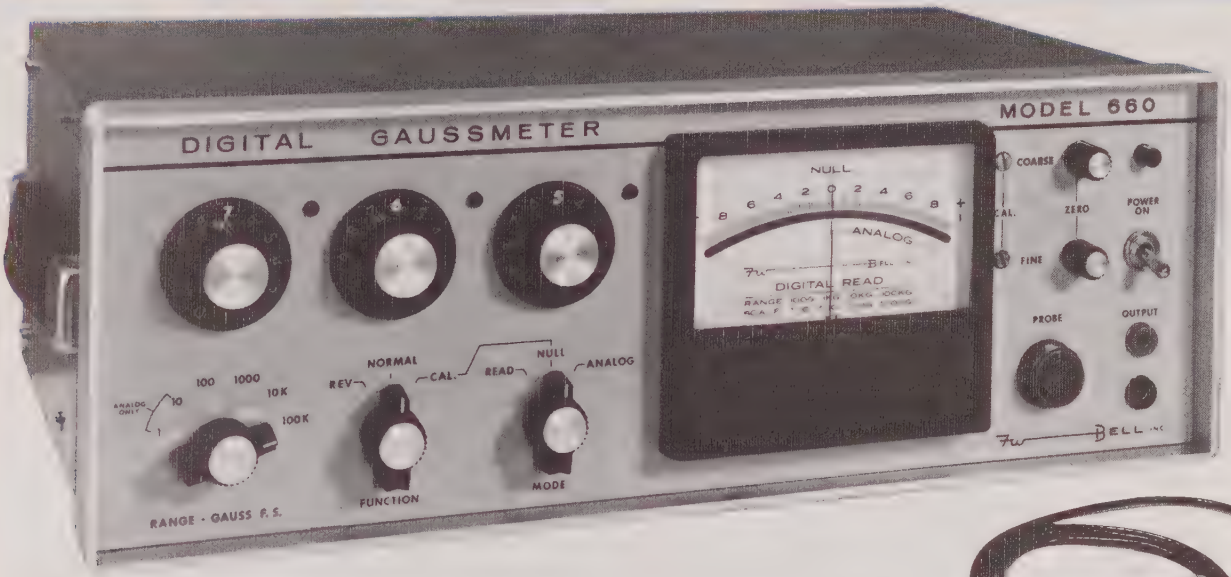
BELL INC.
6120 Hanging Moss Rd.
Orlando, FL 32807
Phone 305/678-6900
TWX: 810-853-3115

specifications subject to change without notice.

F.W. BELL INC.

DIGITAL GAUSSMETER

MODEL 660



APPLICATIONS

Air Gap—Laboratory Electromagnets:

Monitor fixed field setting.
Incremental changes in large fields.
Monitor fixed or varying fields at remote positions using external digital voltmeter (DVM).
Record continuous swept-fields (mass spectrometer).
Field control systems.

General-Purpose R & D:

Accurate flux density measurements on magnetic and electromagnetic components such as relays, dc motors, loudspeaker and other electroacoustic devices, reed switch bias magnets.
Shielding effectiveness.

Microwave Systems:

Test, analyze and record magnetic field properties of Ferrite isolators, magnetrons, travelling wave tubes and YIG filters.

Manufacturing and Quality Control:

Incoming inspection and quality control standards.
In-line production testing.
Sample evaluation, magnetic properties tests.
Evaluation of magnet charging and pullback equipment.
Control of flux level during magnet pullback process.
High-resolution field strength evaluation.

FEATURES

- ***Digital & Analog Readout***
- ***±0.1% Accuracy to 10 kG***
- ***2 Parts in 10^5 Resolution FS***
- ***100 kG Suppression Capability***
- ***Built-in Calibration Accuracy ±0.2%***
- ***Excellent Short & Long Term Stability***

GENERAL DESCRIPTION

The Model 660 Digital Gaussmeter represents an attempt to combine state-of-the-art developments in Hall generators with the latest solid-state instrument circuitry. New Hall generators with linear flux response and high thermal stability have opened the door to the design of a vastly improved gaussmeter. The Model 660 provides the correct driving source and load impedances so necessary for high-accuracy performance of the Hall probe. Solid-state voltage regulated amplifiers and a current regulated element supply are used. Packaged in an attractive metal housing, the unit features ruggedly built modular construction suitable for laboratory or shop environment. A rack-mounted version is also available.

REPLACEMENT FEBRUARY 1977 Litho in U.S.A. Number 60660

MODEL 660 DIGITAL GAUSSMETER

THEORY OF OPERATION

The basic principle of magnetic flux measurement used in the Model 660 Gaussmeter may be described as a flux-modulated carrier-amplifier system. The output from the Hall generator is accurately proportional to flux density. A locally generated 1 kHz ac carrier signal, fed as an exciting current to the Hall element, causes input chopping action. The result is an ac Hall output when the probe is placed in a static (dc) field.

The ac flux modulated carrier signal is amplified and then restored to dc in the synchronous demodulator without loss of polarity or field direction information. The dc signal drives the panel meter. The same signal is also filtered, amplified and made available at the output jacks for external use.

Digital operation is obtained by the method of zero suppression and scale expansion. A separate input carrier signal, controlled by the digital attenuator dials and in phase opposition to the flux signal, is introduced to a resistive summing circuit. By careful control of phase, this calibrated digital signal can completely cancel the flux signal, suppressing the meter to zero. This permits amplifier gain to be increased 1000 times, resulting in 1000 X scale expansion. Small incremental changes in flux density are read directly on the meter in the digital READ mode.

SPECIFICATIONS

Operating Modes:

1. Analog mode with linear meter scale readout and analog flux-proportional output voltage.
2. Digital NULL mode using 3 manually operated digit dials and null meter.
3. Digital READ mode using 3 manually operated digit dials plus linear scale meter interpolation of the 3rd digit.

Ranges:

Measurement of static (dc) or varying magnetic field strength in the range of 0.1 gauss full scale to 30,000 gauss (10 microtesla to 3 tesla) in decade ranges as follows:

FULL SCALE RANGE Analog Mode	FULL SCALE RANGE Digital Mode	SENSITIVITY-FULL SCALE Digital Mode
1 gauss	—	—
10 gauss	—	—
100 gauss	100 gauss	0.1 gauss
1000 gauss	1000 gauss	1 gauss
10 kgauss	10 kgauss	10 gauss
100 kgauss	100 kgauss	100 gauss

Probes with a sensitivity of 10X will decrease the above numbers by a factor of 10.

Resolution of Readout:

1. Analog Mode—50-0-50 division meter scale, 2% FS per div.
2. Digital NULL mode—3 digit dials or 1 part in 1000 of full scale.
3. Digital READ mode—3 digit dials plus linear meter scale interpolation to obtain maximum 2 parts in 10^5 per scale division.

CALIBRATION

Factory calibration determines a CAL CONSTANT for each individual probe. This calibration is achieved by the use of a reference magnet which is traceable to the National Bureau of Standards. The accuracy of the internal calibration feature of the 660 using the probe CAL CONSTANT is ±0.2% of the reading. Calibration to a higher precision can be accomplished by using a suitable external standard field.

ACCURACY

Instrument accuracy is ±0.1% of the reading through 10,000 gauss (1 tesla) and ± 0.3% of the reading through 100,000 gauss (10 tesla). Total accuracy is the sum of the instrument accuracy plus calibration accuracy plus probe accuracy.

An individual, machine-plotted probe error curve showing deviations from true linearity, usable for readout corrections, is available as a probe option.

Stability:

1. Short-term — no measurable drift in 1 hour @ 25° C.
2. Long-term — ± 1 digit per 8 hours @ 25°C.

Output Jacks:

Output voltage — 1.0 volt dc full scale

Power Supply: ac line operation 115/230V, 50/60 Hz.

DIMENSIONS: 6⅛″ (155.6 mm) high; 16½″ (419.1 mm) wide; 12½″ (317.5 mm) deep

WEIGHT: Shipping 18 lbs (8.1 kg); net 12 lbs (5.4 kg)

PROBES

More than 110 different probes are available for use with the 660 gaussmeter to meet the requirements of virtually any application. Please see F. W. Bell Gaussmeter Probes literature sheet #60700 for probe models, specifications, and prices. Consult the factory for special probe requirements.

Printed in U.S.A. Specifications subject to change without notice.

F W BELL INC.
A Subsidiary of The Arnold Engineering Company
4949 Freeway Drive East
Columbus, Ohio 43229
Phone: (614) 888-7501
TWX: 810-337-2851

PRECALIBRATED GAUSSMETERS

620/640

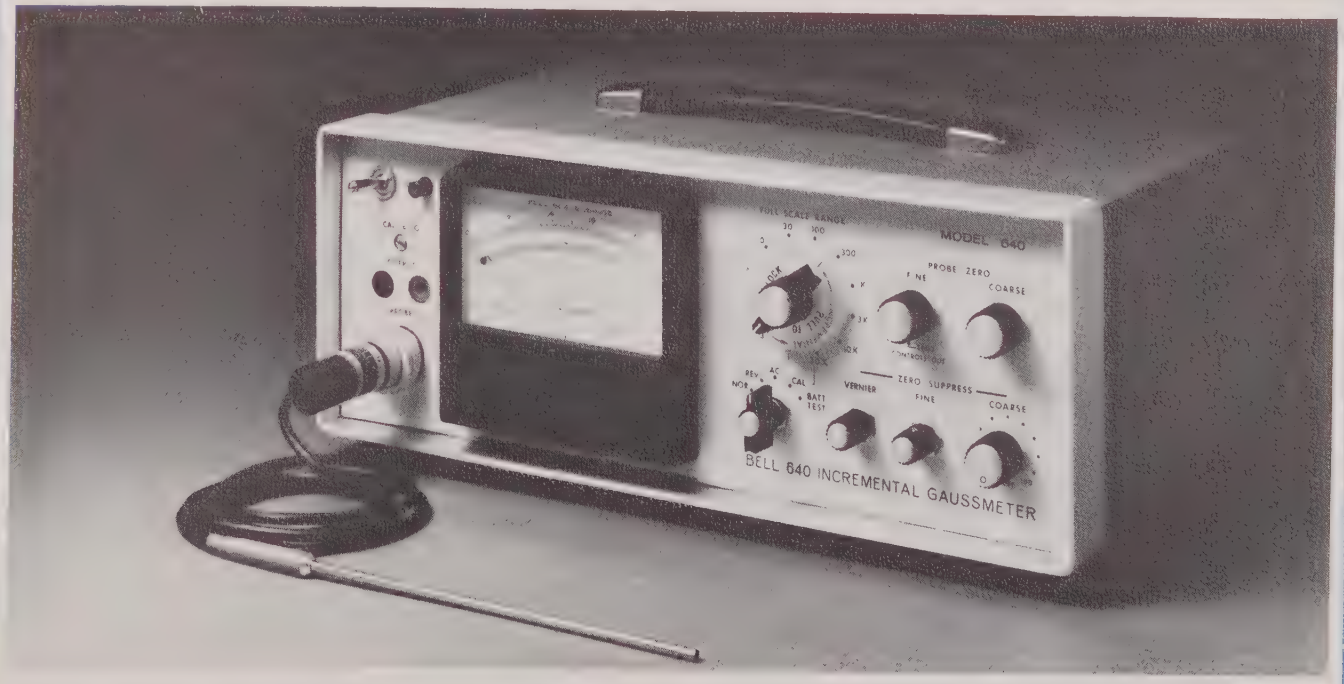
FEATURES:

- 1000X Scale Expansion* (with zero center readout)
- 2 parts in 10^5 Resolution*
- Precalibrated Probes (probe interchangeable without recalibration)
- 0.3% built-in Calibration Accuracy
- Temperature Stable Probes
- Direct ac & dc Field Readout
- 5 volt dc Auxiliary Output**
- 100 kG Probe Capability

GENERAL DESCRIPTION:

The Model 620 and 640 Gaussmeters are precision instruments designed to take advantage of the new high-performance Bell Hall generators. Unique design allows a number of features not formerly available. A new precalibration technique allows direct interchangeability of probes without recalibration. With built-in calibration accuracy of ±0.3%, instrument accuracy is ±0.8% to 30 kG (3 tesla) and ±0.4% to 10 kG (1 tesla) when used with the new probes. All probes are calibrated at the factory by referencing to a laboratory standard magnet. Controlled feedback permits incremental operation up to 30 kG.* 1000X scale expansion with zero center meter readout permits direct measurement of small incremental variations in both a positive and negative direction.*

The instruments offer twelve (12) ranges, overlapping from 0.1 gauss (10^{-5} tesla) FS to 30 kG (3 tesla) FS. With appropriate Probe, 100 kG measurements possible. Both dc and ac fields are indicated directly on the panel meter. AC fields up to 400 Hz are read out as an RMS value for sine wave fields. A calibrated output voltage of 1 V FS is available at the output jacks located on the front panel allowing connection to higher accuracy instrumentation such as DVM. An auxiliary output, located on the rear panel, is adjustable from 1 V to 5 V FS to provide increased output voltage and power to drive external equipment.** The Gaussmeters offer automatic change-over to battery operation in case of a power failure, making the instrument ideal for fixed installations where constant, non-interrupted service is required. Simplified operation plus a variety of high stability probes makes the 620 and 640 ideal instruments for laboratory, field and production applications.



Model 640 Gaussmeter

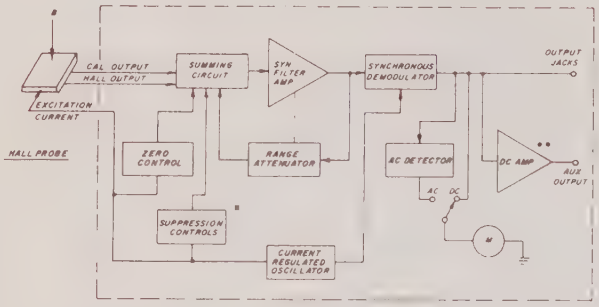
*Offered with 640 only **Optional with 620

REVISED APRIL 1980 Printed in USA NUMBER 60650

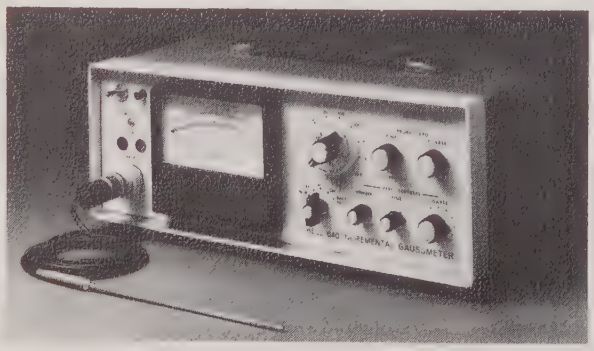
THEORY OF OPERATION:

The basic principle of magnetic field measurement used in the Model 620/640 Gaussmeters can be described as a field-modulated carrier-amplifier system. The Hall element is fed by a locally generated current regulated excitation signal which causes input chopping action. When the Hall element is placed in the field, a field modulated ac carrier output voltage is produced.

620/640 Gaussmeter



Each probe provides the Hall output voltage and the calibration output. These outputs are applied to the summing circuit along with the zero control output, suppression controls output and feedback range attenuator. The zeroing voltage removes the Hall elements residual output to zero the instrument under the conditions of zero field. The suppression controls buck out the absolute field output of the Hall element so that scale expansion can be applied for incremental operation.* High stability amplification is supplied by the synchronous filter amplifier and feedback attenuator combination. The amplified carrier is then restored to a field proportional voltage by the synchronous demodulator, without loss of polarity (field direction) information. This output feeds the output jacks and meter for dc fields. If the field is time varying, the demodulated output will be instantaneously proportional to the field waveform up to 400 Hz. A separate detector converts the ac portion of the output to dc for meter readout providing separation and independent readout for ac and dc fields.



Model 620 Gaussmeter

* Offered with 640 only
** Optional with 620

SPECIFICATIONS:

Field Range: 12 range non-overlapping from 0.1 G (10^{-5} tesla) full scale to 30 kG (3 tesla) full scale.

.1	1	10	100	1,000	10,000
.3	3	30	300	3,000	30,000

Field measurements can be extended to 100 kG with appropriate probes.

Absolute Measurement Accuracy: Using internal calibration feature ±0.8% FS to 30 kG (3 tesla) and ±0.4% FS to 10 kG (1 tesla) with high performance probes.

Incremental Measurement Accuracy: Using internal calibration feature ±1.0% FS to ±3.0% FS depending on probe type and absolute field magnitude.*

Scale Expansion: 1000X with automatic and true zero center meter incremental readout.*

Meter Scale Resolution: For absolute measurements, one minor scale division is 1.0% of full scale reading. On 0.1 gauss (10^{-5} tesla) range, this represents 0.001 gauss (10^{-7} tesla) resolution. For incremental measurements, one minor scale division is 0.002% of full scale absolute range setting. On 100 gauss range, this represents 0.002 gauss or 2 parts in 10^5 resolution.

Zero Suppression: Up to 30 kG fields may be suppressed to Zero.*

Stability: Temperature stable probes offer temperature dependence of ±0.005% of reading per degree C mean value from −20°C to 60°C.

Meter Readouts: Direct and independent reading of dc static flux density and RMS value of ac fields (sine wave 10 to 400 Hz). See instruction manual for field rejection capability.

Calibration: Internal calibration technique allows changing probes without recalibration. Internal calibration error does not exceed ±0.3%. Can be calibrated to higher precision with suitable external standard field.

Output: Calibrated dc voltage of 1.0 volt FS is available at output jacks on front panel. Output impedance is approximately 1 kΩ. An auxiliary output, adjustable to 5 V dc, appears at the auxiliary output jacks located in the rear of the instrument.** Fields dc up to 400 Hz can be measured at the output jacks using an oscilloscope or external indicator.

Power Supply: AC line operation 115/230 V, 50/60 Hz; Internal battery (12 V dry battery, Neda 923 — Eveready 2780N or equivalent) furnished as optional accessory. External battery input 9 to 18 V dc available at rear of the instrument. When batteries are used, automatic takeover feature is available in case of the line power failure.

Accessories: 12 V dry battery, Neda 923 — Eveready 2780N or equivalent allows internal battery operation and can be used for external battery operation.

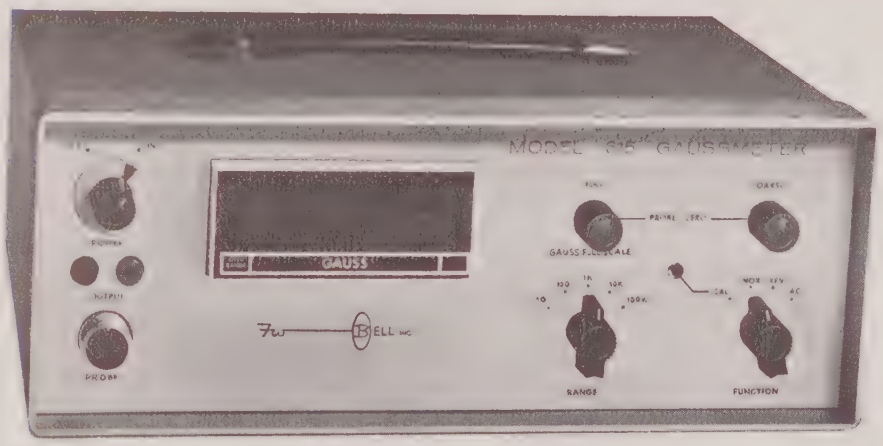
Dimension: 5¾" high, 15" wide, 10⅜" deep.

Weight: Shipping 18 lbs., net, 12 lbs.

HALL EFFECT GAUSSMETERS

MAGNETIC FIELD PROBES

SHORT FORM CATALOG



New 615 Digital Gaussmeter

Magnetic field measurement instrumentation

for every application.

F W BELL INC.

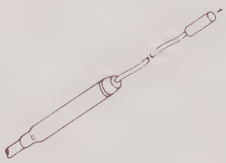
REVISION EFFECTIVE 1 MARCH 80 Litho in USA NUMBER 60730

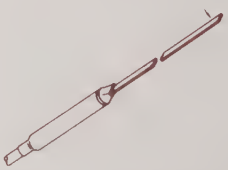
GAUSSMETERS

NEW LINE
1600.00
9200
3000.00
9500
.15%
50kHz
9900
5000.00
NO LONGER MAKE THE 600 SERIES

			Incremental 640
			$1735
		00,000	12 ranges—0.1 to 30,000 gauss full scale
		o 10 kG o 30 kG	±.25% FS
			dc to 400 Hz fields
			1 volt dc FS, 5 volt dc FS
		2 parts in 10^5	2 parts in 10^5
readout	analog/digital, BCD	digital or analog	analog
power	115/230 Vac, 50/60 Hz	115/230 Vac, 50/60 Hz	115/230 Vac, 50/60 Hz or battery
size	8½" x 8½" x 14"	6" x 17" x 12"	5¾" x 15" x 10⅜"
shipping weight	20 pounds	18 pounds	18 pounds
special features	100 ppm/°c stability internal calibration accuracy of ±0.1% of reading traceable to NBS modular construction	excellent short and long term stability internal calibration accuracy of ±0.2% of reading	1000 x scale expansion precalibrated probes 100 kG probe capability internal calibration accuracy of ±0.3% of reading
literature reference	Magnetic Field Monitor model 810 literature	Digital Gaussmeter model 660 literature	Precalibrated Gaussmeter model 620/640 literature

PROBES

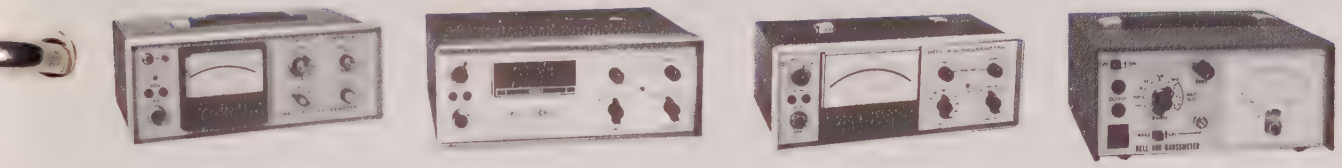




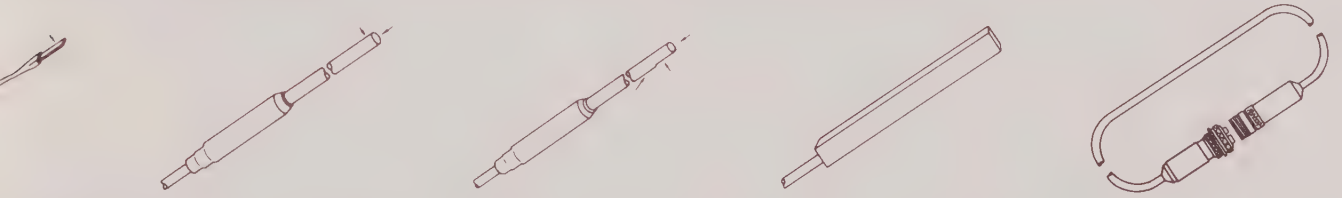
There are over 110 different magnetic field probes to meet the challenging electrical and mechanic

model	Axial	Axial Flexible	Transverse	Transverse
field direction sensed	the direction of the probe axis	the direction of the probe axis	perpendicular to the probe axis	perpendicu probe ax
field range sensed	0.1 gauss FS to 100 kgauss FS	0.1 gauss FS to 100 kgauss FS	0.1 gauss FS to 100 kgauss FS	0.1 gauss F 100 kgauss
stem material	aluminum or phenolic	flexible	aluminum, epoxy, or phenolic	flexible
stem length	2" to 60"	15" typical	2" to 60"	15" typical
literature reference	Bell Gaussmeter Probe literature sheet			
applications	general purpose high field high linearity cryogenic	special fixturing applications	general purpose high field high linearity cryogenic	special fixt applicati

Jim Robins ARCADIA 818 574-0049



recalibrated 620	Digital 615	Self-calibrated 610	General purpose 600/600A
$1240	$1180	$860	$385/$450
2 ranges—0.1 to 30,000 gauss full scale	5 ranges—10 gauss to 1 Mg full scale	11 ranges—1 to 100,000 gauss full scale	6 ranges—100 to 30,000 gauss full scale
.25% FS	±.5% FS	±.5% FS	±4% FS
c to 400 Hz fields	dc to 2kHz	dc to 2kHz	dc to 5,000 Hz fields
volt dc FS	100 mV dc FS	100 mV dc FS	1 volt dc FS
part in 10^2	1 part in 10^3	1 part in 10^2	1 part in 50
nalog	3½ digits/analog/BCD	analog	analog
15/230 Vac, 50/60 Hz or battery	115/230 Vac, 50/60 Hz	115/230 Vac, 50/60 Hz or battery	115/230 Vac, 50/60 Hz (600A) or battery (600)
¾" x 15" x 10⅜"	5¾" x 15" x 9⅜"	5¾" x 15" x 9⅜"	4½" x 8¼" x 8¼"
6 pounds	15 pounds	15 pounds	12 pounds
recalibrated probes 00 kG probe capability rect ac & dc field readout internal calibration accuracy of ±0.3% of reading	direct ac & dc field readout digital self-calibrating probes internal calibration accuracy of ±0.5% of reading	direct ac & dc field readout self-calibrating probes internal calibration accuracy of ±0.5% of reading	portable integrated circuit design internal calibration accuracy of ±3% of reading
recalibrated Gaussmeter model 620/640 literature	Digital Gaussmeter model 615 literature	Self-calibrated Gaussmeter model 610 literature	General Purpose Gaussmeter model 600 literature



l requirements of virtually any application.

lexible	Two Axis	Three Axis	Magnaprobe	Extension Cables
r to the	two perpendicular directions, one is the probe axis	three perpendicular directions, one is the probe axis	the direction of the probe axis	not applicable
to S	0.1 gauss FS to 10 kgauss FS	0.1 gauss FS to 10 kgauss FS	.001 gauss FS to 2 gauss FS	not applicable
	aluminum	aluminum	lexan	not applicable
	2" to 36"	2" to 36"	9"	10', 25', 50', and 100'
		Bell Gaussmeter Probe literature sheet		
ng s	two axis field measurements	three axis field measurements	high sensitivity field measurements 1 gamma resolution	for remote location of instrumentation

Specifications subject to change without notice.

BELOW IS A LISTING AND A DESCRIPTION OF SOME OF THE AVAILABLE F.W. BELL LITERATURE SHEETS.

HALL GENERATORS

60920 — This is a complete description with features and electrical specifications for the Bell cryogenic, high linearity, high field Hall generators.

69900 — This literature describes BH-200 series Bell general purpose Hall generators. There are 10 individual Hall generators to meet the physical and electrical requirements of most general purpose applications.

69901—This describes the BH-700 single axis series Bell Hall generators. There are five different models to meet the requirements of many general purpose applications.

69902—This describes the two axis and three axis Bell Hall generators. These Hall generators sense magnetic field strength in more than one axis.

70020—The high sensitivity Hall generator, BH-850, is designed to measure fields in the low field region.

70050—This literature describes the FH-300 series low-cost Hall generators. There are two models to meet the requirements of many applications.

TRANSDUCERS

60801—This sheet describes the R-2000 series Bell Watt and Var Transducers. It includes sections on "Why utilize the Hall Effect", performance and complete specifications.

60802 — This describes the R-2000 series Current and Voltage Transducers. It includes sections on "Why use two section Transducers" and performance; and discusses desirable qualities of voltage and current transducers.

60845—This sheet describes PX-2000 and PX-4000 series Bell Industrial Watt Transducers. The sheet includes a section on applications, typical wiring diagrams and power measurement theory.

GAUSSMETERS

60639—This sheet has descriptions, features, applications and specifications of the model 600 and 600A General Purpose Bell Gaussmeter.

60640 — This describes the model 610 Bell gaussmeter and its application and specifications.

60645—This describes the model 615 Bell gaussmeter and its applications and specifications.

60650 — This literature describes the 620 and 640 series Bell gaussmeters. It contains sections on probe configurations, options, specifications, and theory of gaussmeter operation.

60660—This describes the model 660 Bell gaussmeter and its applications.

60680—This literature describes model 810 and 811 Bell gaussmeters. It includes specifications and features.

60704—This sheet is a comprehensive list of all Bell gaussmeter probes. There are over 110 different models of different mechanical and electrical specifications.

60705—This sheet describes the Bell probes designed to replace obsolete probes for obsolete gaussmeter models 110, 120, and 240.

60733 — Gaussmeter Differential Probes literature describes the new differential probe for making differential field measurements. It includes a section on operation and probe linearity.

60710 — This sheet cross-references old obsolete probes with the new third generation probes described on sheet 60704.

60730—This is the brochure you presently have in your hands.

MAGNET PROCESSING

61020 — The magnet proccessing equipment brochure describes Bell magnetizers, stabilizers and fixtures. It includes specifications and photographs of a number of applications.

60681—The Magnet Sorter literature describes the 813 Bell magnet sorter and lists applications and specifications.

See the Representative listing sheet for your local Representative.

6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

FW Subsidiary, Magnetics & Electronics, Inc. BELL INC.

Printed in U.S.A.

GAUSSMETER OPTIONS:

The Model 620 and 640 Gaussmeters offer a number of options to meet a variety of applications. These options are denoted by a letter suffix to the model number (example: 620R-Rack mount 620). The options are:

D — 5 volt dc auxiliary Output
N — Narrow Banding (dc to 10 Hz)
R — Rack Mount
Z — Zero Center Meter

Option D and Z are standard with the Model 640 Gaussmeter. The following configuration options are available:

Model number and options included.

640N:	Narrow banding
640R:	Rack mount
640NR:	Narrow banding, rack mount
620D:	5 vdc. auxiliary output
620N:	Narrow banding
620R:	Rack mount
620Z:	Zero center meter
620DN:	5 vdc. aux. output, narrow banding
620DR:	5 vdc. aux. output, rack mount
620DZ:	5 vdc. aux. output, zero center meter
620NR:	Narrow banding, rack mount
620NZ:	Narrow banding, zero cntr. mtr.
620RZ:	Rack mount, zero cntr. mtr.
620DNR:	5 vdc. aux. output, narrow banding, rack mount
620DNZ:	5 vdc. aux. output, narrow banding, zero cntr. mtr.
620DRZ:	5 vdc. aux. output, rack mtg., zero cntr. mtr.
620NRZ:	Narrow banding, rack mtg., zero cntr. mtr.
620DNRZ:	5 vdc. aux. output, narrow banding, rack mount, zero center meter.

The factory should be contacted for assistance if an application requires a configuration other than that defined above.

PROBE CONFIGURATIONS:

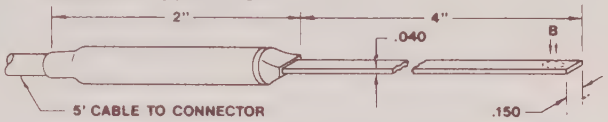
The Bell new standard line probes are designed to fill a large variety of customer applications and requirement. The probes provide stable and repeatable magnetic field measurements by being carefully matched to electrical input characteristics of the 620 and 640 Gaussmeters. There are five (5) classes of probes offered. They are:

Standard
Heavy Duty
Flexible
Cryogenic
Special Purpose

The classes offer a wide variety of Hall sensors mounted in graduated stem types and lengths to provide the mechanical and electrical characteristics required for most magnetic field measurements.

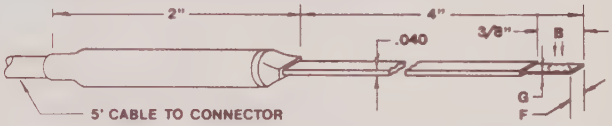
STANDARD PROBES (S Class)

Transverse Type (Rigid Stem)



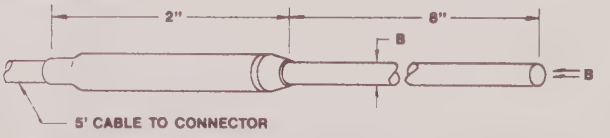
Model No.	Linearity	Range Mult.	Active Area	Op. Temp. Range	Temp. Stab.
STB4-0404	1.0% to 10 kG	1X	.070" Dia.	0°C to +75°C	−0.04 % /°C
STG4-0404	2.0% to 30 kG	1X	.070" Dia.	0°C to +75°C	−0.04 % /°C
STJ4-0404	0.1% to 10 kG	10X	.040" Dia.	0°C to +75°C	−0.005 % /°C
STL4-0404	0.25% to 30 kG	10X	.040" Dia.	0°C to +75°C	−0.005 % /°C
STR4-0404	1.0% to 100 kG	10X	.040" Dia.	0°C to +75°C	−0.005 % /°C

Transverse Type (Half Encapsulated)



Model No.	Dimension F	Dimension G	Linearity	Range Mult.	Active Area	Op. Temp. Range	Temp. Stab.
STB4-0204	.130" ±.003	.020" ±.003	1.0% to 10 kG	1X	.070" Dia.	0°C to +75°C	−0.04 % /°C
STG4-0204	.130" ±.003	.020" ±.003	2.0% to 30 kG	1X	.070" Dia.	0°C to +75°C	−0.04 % /°C
STE4-0104	.080" ±.003	.015" ±.003	2.0% to 10 kG	1X	.040" Dia.	0°C to +75°C	−0.08 % /°C
STI4-0004	.135" ±.003	.010" ±.003	3.0% to 10 kG	1X	.030" Dia.	0°C to +75°C	−0.10 % /°C

Axial Type



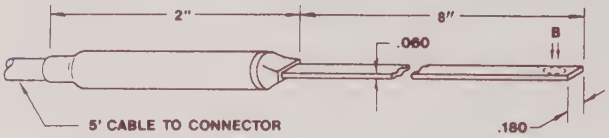
Model No.	Dem. B	Linearity	Range Mult.	Active Area	Op. Temp. Range	Temp. Stab.
SAE4-0808	.080" ±.003"	2.0% to 10 kG	1X	.020" Dia.	0°C to +75°C	−0.08 % /°C
SAB4-1208	.120" ±.003"	1.0% to 10 kG	1X	.030" Dia.	0°C to +75°C	−0.08 % /°C
SAB4-1808	.180" ±.003"	1.0% to 10 kG	1X	.030" Dia.	0°C to +75°C	−0.04 % /°C
SAG4-1808	.180" ±.003"	2.0% to 30 kG	1X	.030" Dia.	0°C to +75°C	−0.04 % /°C
SAK4-1808	.180" ±.003"	0.25% to 10 kG	10X	.030" Dia.	0°C to +75°C	−0.005 % /°C
SAN4-1808	.180" ±.003"	0.5% to 30 kG	10X	.030" Dia.	0°C to +75°C	−0.005 % /°C
SAR4-1808	.180" ±.003"	1.0% to 100 kG	10X	.030" Dia.	0°C to +75°C	−0.005 % /°C

620/640 PRECALIBRATED GAUSSMETERS

SEE SALES BROCHURE #60700 FOR COMPLETE SPECIFICATIONS FOR THE MORE THAN 110 PROBES AVAILABLE FOR THE 620 OR 640

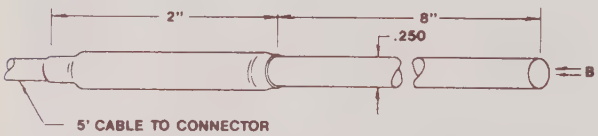
HEAVY DUTY PROBES (H Class)

Transverse Type



Model No.	Linearity	Range Mult.	Active Area	Op. Temp. Range	Temp. Stab.
HTB4-0608	1.0% to 10 kG	1X	.070" Dia.	0°C to +75°C	−0.04 % /°C
HTG4-0608	2.0% to 30 kG	1X	.070" Dia.	0°C to +75°C	−0.04 % /°C
HTJ4-0608	0.1% to 10 kG	10X	.040" Dia.	0°C to +75°C	−0.005 % /°C
HTL4-0608	0.25% to 30 kG	10X	.040" Dia.	0°C to +75°C	−0.005 % /°C
HTR4-0608	1.0% to 100 kG	10X	.040" Dia.	0°C to +75°C	−0.005 % /°C

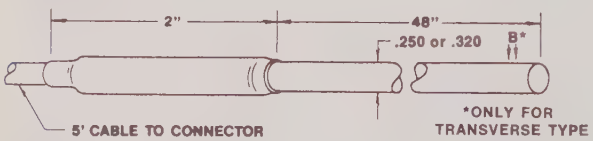
Axial Type



Model No	Linearity	Range Mult.	Active Area	Op. Temp. Range	Temp. Stab.
HAB4-2508	1.0% to 10 kG	1X	.030" Dia.	0°C to +75°C	−0.04 % /°C
HAG4-2508	2.0% to 30 kG	1X	.030" Dia.	0°C to +75°C	−0.04 % /°C
HAK4-2508	0.25% to 10 kG	10X	.030" Dia.	0°C to +75°C	−0.005 % /°C
HAN4-2508	0.5% to 30 kG	10X	.030" Dia.	0°C to +75°C	−0.005 % /°C
HAR4-2508	1.0% to 100 kG	10X	.030" Dia.	0°C to +75°C	−0.005 % /°C

CRYOGENIC PROBES (C Class)

Transverse Type



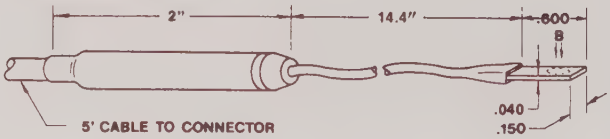
Model No.	Linearity	Range Mult.	Active Area	Op. Temp. Range	Temp. Stab.
CTP4-3248	1.0% to 30 kG	10X	.040" Dia.	−269°C to +75°C	−0.005 % /°C
CTU4-3248	2.0% to 100 kG	10X	.040" Dia.	−269°C to +75°C	−0.005 % /°C

Axial Type

Model No.	Linearity	Range Mult.	Active Area	Op. Temp. Range	Temp. Stab.
CAP4-2560	1.0% to 30 kG	10X	.030" Dia.	−269°C to +75°C	−0.005 % /°C
CAU4-2560	2.0% to 100 kG	10X	.030" Dia.	−269°C to +75°C	−0.005 % /°C

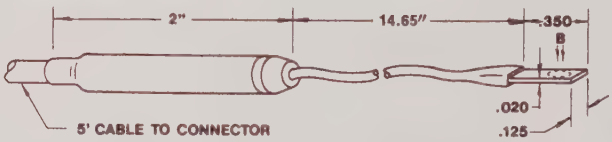
FLEXIBLE PROBES (F Class)

Transverse Type



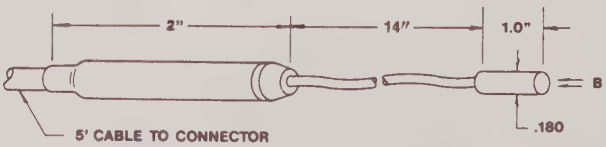
Model No.	Linearity	Rance Mult.	Active Area	Op. Temp. Range	Temp. Stab.
FTB4-0415	1.0% to 10 kG	1X	.070" Dia.	0°C to +75°C	−0.04 % /°C
FTG4-0415	2.0% to 10 kG	1X	.070" Dia.	0°C to +75°C	−0.04 % /°C
FTJ4-0415	0.1% to 10 kG	10X	.040" Dia.	0°C to +75°C	−0.005 % /°C
FTL4-0415	0.25% to 10 kG	10X	.040" Dia.	0°C to +75°C	−0.005 % /°C
FTR4-0415	1.0% to 100 kG	10X	.040" Dia.	0°C to +75°C	−0.005 % /°C

Transverse Type



Model No.	Linearity	Range Mult.	Active Area	Op. Temp. Range	Temp. Stab.
FTB4-0215	1% to 10 kG	1X	0.70" Dia.	0°C to +75°C	−0.04 % /°C
FTG4-0215	2% to 30 kG	1X	0.70" Dia.	0°C to +75°C	−0.04 % /°C
FTJ4-0215	.1% to 10 kG	10X	0.40" Dia.	0°C to +75°C	−0.005 % /°C

Axial Type



Model No.	Linearity	Range Mult.	Active Area	Op. Temp. Range	Temo. Stab.
FAB4-1815	1.0% to 10 kG	1X	.030" Dia.	0°C to +75°C	−0.04 % /°C
FAG4-1815	2.0% to 30 kG	1X	.030" Dia.	0°C to +75°C	−0.04 % /°C
FAK4-1815	0.25% to 10 kG	10X	.030" Dia.	0°C to +75°C	−0.005 % /°C
FAN4-1815	0.5% to 30 kG	10X	.030" Dia.	0°C to +75°C	−0.005 % /°C
FAR4-1815	1.0% to 100 kG	10X	.030" Dia.	0°C to +75°C	−0.005 % /°C

Specifications subject to change without notice.

Subsidiary, Magnetics & Electronics, Inc.

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

DIGITAL GAUSSMETER

MODEL 615

DESCRIPTION

The Model 615 Bell Gaussmeter is a high quality digital instrument designed for general field measurement applications. The Model 615 incorporates the top quality normally associated with Bell gaussmeters, yet sports a price competitive with other gaussmeters possessing far fewer features. Instrument accuracy is 0.5% full-scale. Instrument sensitivity ranges from a 0 to 10 gauss (10^{-3} Tesla) range to a 0 to 100 kilogauss (10 Tesla) range. It operates from 115/230 volts ac line.

This accuracy, range, and inherent reliability of the 615 make it suitable for general lab applications and a wide variety of manufacturing applications. The application section lists a number of present applications. A TTL compatible BCD output is available on the rear panel.

Over 110 different magnetic field measurement probes are available for use with the 615 gaussmeter. The different physical and electrical characteristics of these probes will match the gaussmeter to nearly every requirement. The 615 uses an internal calibration function to adapt it to each individual probe. Please see the "Gaussmeter Probes" literature sheet for further probe information.

Bell gaussmeters are compact, high quality, solid-state instruments designed to measure magnetic flux density. Each unit contains the measurement circuitry, the read-out device, electrical proportional outputs, and the appropriate controls on the front panel. One or more magnetic field probes are required for gaussmeter operation. The probe contains a Hall element and plugs into the gaussmeter front panel to provide a signal related to flux density. Gaussmeters and probes may be used in a wide variety of magnetic field measurements. These include measurements that are fixed or hand-held, high field and low field, high accuracy, low temperature, manufacturing or laboratory. F. W. Bell has many years of experience and expertise in magnetic field measurements. If you have a new or unusual application, or you just need basic information on magnetic field measurements, please contact us.

REVISED APRIL 1980 Printed in USA NUMBER 60645

MODEL 615 DIGITAL GAUSSMETER

SPECIFICATIONS

Field Range 5 ranges, nonduplicating, from 10G (10^3 Tesla) FS to 100 kG* (10 Tesla) FS.

10 G** 100 G 1 k G 10 kG 100 kG*
10^{-3} Tesla 10^{-2} Tesla 10^{-1} Tesla
1 Tesla 10 Tesla

*Probes available to 250 kG in 0-100 kG range. 10x probes only.
**1x probes only.

Instrument Accuracy 0.5% FS

Calibration Accuracy 0.5% of reading
Total accuracy is instrument accuracy + calibration accuracy + probe accuracy.

Meter Scale Resolution One digit read-out is 0.1% of full-scale reading. On the 10 gauss (10^{-3} Tesla) range this represents 0.01 gauss (10^{-6} Tesla) resolution.

Meter Read-Out Direct reading of dc static flux density and RMS value of ac field 3½ digit read-out with switchable decimal.

Calibration Probes can be easily calibrated using the internal calibration feature. Internal calibration error does not exceed ± 0.5%. Can be calibrated to higher precision with suitable external standard field.

Output Calibrated dc voltage of 100 mV FS is available at output jacks on front panel. Output impedance is approximately 10 kΩ, ac fields up to 2kHz can be displayed and measured at the output jacks using an oscilloscope or external indicator. TTL compatible BCD is available on the rear panel.

Power Supply AC line operation 115/230 V, 50/60 Hz.

Dimensions 5¾" (146 mm) high; 15" (381 mm) wide; 9⅜" (235 mm) deep.

Weight shipping 15 pounds (6.8 kg), net 9 pounds (4.1 kg).

FEATURES

- **3½ digit read-out with BCD**
- **Direct ac and dc field read-outs**
- **0.5% FS accuracy**
- **5 full-scale ranges for any one probe**
- **Analog signal of 0-100 mV dc FS**

APPLICATIONS

- Testing, sorting, classifying magnets.
  Traveling wave tube magnet testing.
  Meters, magnetic chucks, quality sampling.

For measurements in the production of such products as:

- Tachometers, magnets, pm motors.
  Relays, solenoids, T.V. deflection coils.
  Magnetic transducers, loudspeakers.

THEORY OF OPERATION

The Model 615 Bell gaussmeter works on a field modulated carrier-amplifier system utilizing a Hall magnetic field sensor to probe the field. The Hall element is fed by a regulated control current. When the Hall element is placed in a field, a field modulated ac output voltage is produced.

Thus, the probe provides a field proportional voltage and a calibration output. The zeroing voltage removes the Hall element's output in order to zero the instrument under the conditions of zero field. Solid-state amplifiers provide high stability amplification. The amplified, modulated carrier is then demodulated to produce a field proportional voltage containing polarity information for dc fields. This output feeds the output jack and meter. Time varying or ac field signals are rectified for direct read-out.

OPTIONS

Also available is the Model 615R digital gaussmeter. This is the rack mounting version of the Bell 615 digital gaussmeter.

Specifications subject to change without notice.

Subsidiary.
Magnetics & Electronics, Inc.
BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

Model
610

SELF-CALIBRATED GAUSSMETER

BELL INC.

GENERAL DESCRIPTION

The Model 610 self-calibrated gaussmeter is a self-contained, direct reading instrument designed specifically for general purpose field applications. The instrument is sensitive to fields as low as 10 milligauss (10^{-6} tesla) and offers eleven (11) ranges, non-duplicating, from (1.0 gauss 10^{-4} tesla) FS to 100 kG (10 tesla) FS.

Instrument accuracy is ±0.5% of full scale; internal calibration accuracy is ±0.5% of reading. A new calibration technique allows interchangeability of probes with simple built-in recalibration feature. All probes are calibrated at the factory by referencing to a laboratory standard magnet which is traceable to the National Bureau of Standards.

Both dc and ac fields are indicated directly on the panel meter. AC fields up to 400 Hz are read out as an RMS value for sine wave fields. A calibrated output voltage of 100 mV FS is available at the output jacks located on the front panel. The Model 610 Gaussmeter offers battery operation as well as ac line operation making the instrument ideal for portable or fixed installation applications. The instrument is available in 5¼" rack mounted configurations on special order.

FEATURES

- *Self-Calibrating Probes (built-in calibration reference)*
- *Direct ac and dc Field Readout*
- *Instrument Accuracy is ±0.5% of Full Scale*
- *AC Line and Battery Operation*
- *11 FS Ranges to 100 kG*
- *Internal Calibration Accuracy is ±0.5% of Reading*

APPLICATIONS

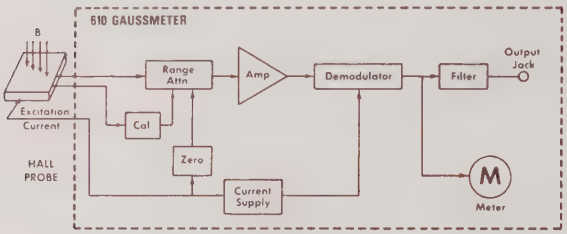
Tachometers, magnets, pm motors.
Relays, solenoids, T.V. deflection coils.
Magnetic transducers, loudspeakers.
Testing, sorting, classifying magnets.
Nondestructive testing by remenance flux.
Switches using magnetic arc blow out.
Traveling wave tube testing.
Thermostats, pressure controls, voltage regulators.
Meters, magnetic chucks, quality sampling.

APRIL 1976 REPLACEMENT Printed in U.S.A. NUMBER 60640

SELF-CALIBRATED GAUSSMETER

THEORY OF OPERATION

The basic principle of magnetic field measurement used in the Model 610 Gaussmeter can be described as a field-modulated carrier-amplifier system. The Hall element is fed by a locally generated current regulated excitation signal which causes input chopping action. When the Hall element is placed in the field, a field modulated ac carrier output voltage is produced.



The probe provides the Hall output voltage and the calibration output. The zeroing voltage removes the Hall elements residual output to zero the instrument under conditions of zero field. High stability amplification is supplied by the solid-state feedback amplifier. The amplified carrier is then restored to a field proportional voltage by the demodulator, without loss of polarity (field direction) information for dc fields. This output feeds the output jacks and meter. Time-varying or ac field signals are rectified for direct readout of ac fields.

SPECIFICATIONS:

Field Ranges: 11 ranges, nonduplicating, from 1.0 G (10^{-4} tesla) FS to 100 kG (10 tesla) FS.

1	10	100	1 kG	10 kG	* 100 kG
3	30	300	3 kG	30 kG	

*Field measurements to 100 kG with high field Probes only.

Accuracy: Total accuracy is instrument accuracy (±0.5% FS) plus calibration accuracy plus probe accuracy.

Meter Scale Resolution: One minor scale division is 1.0% of full scale reading. On 1.0 gauss (10^{-4} tesla) range, this represents 0.01 gauss (10^{-6} tesla) resolution.

Meter Readout: Direct reading of dc static flux density and RMS value of ac fields (sine wave 10 to 400 Hz). Taut band meter suspension.

Calibration: Internal calibration technique allows changing probes with built-in recalibration. Internal calibration error does not exceed ±0.5%. Can be calibrated to higher precision with suitable external standard field.

Output: Calibrated dc voltage of 100 mV FS is available at output jacks on front panel. Output impedance is approximately 10 kΩ. AC fields up to 400 Hz can be displayed and measured at the output jacks using an oscilloscope or external indicator.

Power Supply: AC line operation 115/230 V, 50/60 Hz; Internal battery (12 V dry battery, Neda 926 — Eveready 732 or equivalent) furnished as optional accessory.

Dimensions: 5¾" (146 mm) high; 15" (381 mm) wide; 9⅜" (235 mm) deep.

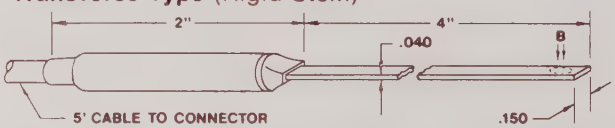
Weight: Shipping 15 pounds (6.8 Kg); Net 9 pounds (4.1 Kg).

Specifications subject to change without notice.

PROBES:

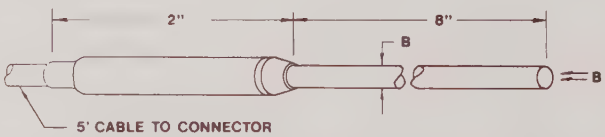
More than 110 probes are available. A few of these probes are described below. Please see the F.W. Bell "Third Generation Gaussmeter Probes" literature sheet for the specifications for all the probes.

Transverse Type (Rigid Stem)



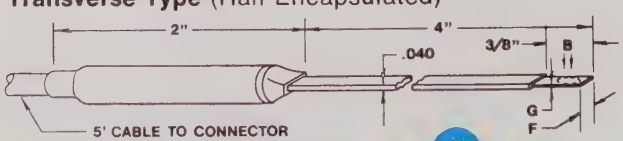
Model No.	Linearity	Range Mult.	Active Area	Op. Temp. Range	Temp. Stab.
STB1-0404	1.0% to 10 kG	1X	.070" Dia.	0° C to +75° C	−0.04 % /°C
STG1-0404	2.0% to 30 kG	1X	.070" Dia.	0° C to +75° C	−0.04 % /°C
STJ1-0404	0.1% to 10 kG	10X	.040" Dia.	0° C to +75° C	−0.005 % /°C
STL1-0404	0.25% to 30 kG	10X	.040" Dia.	0° C to +75° C	−0.005 % /°C
STR1-0404	1.0% to 100 kG	10X	.040" Dia.	0° C to +75° C	−0.005 % /°C

Axial Type



Model No.	Dem. B	Linearity	Range Mult.	Active Area	Op. Temp. Range	Temp. Stab.
SAE1-0808	.080" ±.003"	2.0% to 10 kG	1X	.020" Dia.	0° C to +75° C	−0.08 % /°C
SAB1-1208	.120" +.000" −.005"	1.0% to 10 kG	1X	.030" Dia.	0° C to +75° C	−0.08 % /°C
SAB1-1808	.180" +.002" −.004"	1.0% to 10 kG	1X	.030" Dia.	0° C to +75° C	−0.04 % /°C
SAG1-1808	.180" +.002" −.004"	2.0% to 30 kG	1X	.030" Dia.	0° C to +75° C	−0.04 % /°C
SAK1-1808	.180" +.002" −.004"	0.25% to 10 kG	10X	.C30" Dia.	0° C to +75° C	−0.005 % /°C
SAN1-1808	.180" +.002" −.004"	0.5% to 30 kG	10X	.030" Dia.	0° C to +75° C	−0.005 % /°C
SAR1-1808	.180" +.002" −.004"	1.0% to 100 kG	10X	.030" Dia.	0° C to +75° C	−0.005 % /°C

Transverse Type (Half Encapsulated)



F.W. BELL INC.
A Subsidiary of The Arnold Engineering Company
4949 Freeway Drive East
Columbus, Ohio 43229
Phone: (614) 888-7501
TWX: 810-337-2851

F.W. BELL INC.

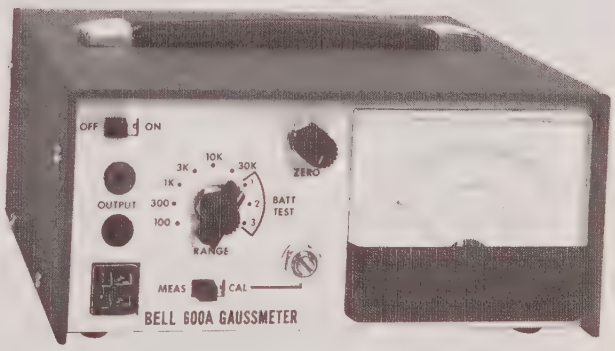
GENERAL PURPOSE GAUSSMETER

Models
600
600A

FEATURES

- *Integrated Circuit Design*
- *Measure dc fields to 30 kG*
- *Built-in Calibration*
- *Two Models-Battery or ac Line Operated*
- *Portable; Simple Design*
- *AC Field Response to 5 k Hz*

Model 600
(Battery Operated)



Model 600A
(ac Line Operated)

APPLICATIONS

Permanent Magnets
Dc and ac Electro-Magnets
Production, Receiving Inspection
Dc and ac Motors
Loudspeaker Design, Inspection
Meters, Vibration Pickups
Relays, Solenoids, Polarized Relays
Magnetic Chucks
Magnetron Testing

GENERAL DESCRIPTION

The Models 600 and 600A represent a significant development in the field of low cost Gaussmeters. As with all F.W. BELL, INC. Gaussmeters, the instrument uses a Hall Element as the basic field sensor. The instruments measure direction and magnitude of magnetic flux density, for plotting flux paths, and for measuring flux leakage. It is designed for use in schools, colleges, research labs, and inspection departments. The instrument can be purchased either battery powered (Model 600) or ac line powered (Model 600A). The ac power supply (Model YB-2062) can be purchased separately as well. The Models 600 and 600A offer self-contained probe calibration and are capable of measuring flux density from 100 to 30,000 gauss, full scale, with a maximum resolution of 2 gauss per division. Output jacks are provided for connection to an external meter, oscilloscope or recorder. The instrument will respond to time varying fields up to 5,000 Hz (cps).

REPLACEMENT APRIL 1976 Printed in U.S.A. NUMBER 60639

Models 600 – 600A GENERAL PURPOSE GAUSSMETER

SPECIFICATIONS

General

The 600 and 600A Gaussmeters utilize Bell Hall generators as flux sensing elements. Each element is constructed of high-stability indium arsenide and located in the tip of a gaussmeter probe.

A new probe configuration offers more flexibility, greater protection against breakage and maintains a minimum probe thickness for small gap applications. Nonmagnetic materials are used throughout the entire probe construction. Standard models are designed to measure flux density in either the axial or transverse probe direction.

See the probe drawings and specifications below.

Ranges:

6 Ranges in Gauss. All ranges are full scale.

100	1,000	10,000
300	3,000	30,000

Accuracy:

±4% of full scale to 30,000 gauss plus the internal calibration accuracy or calibration magnet accuracy plus probe accuracy.

Calibration:

Unit may be calibrated using a standard magnet or the built-in probe calibration feature. Built-in calibration accuracy is ±3%.

Meter Scale Resolution:

One minor scale division is 2.0%. On 100 gauss range, this represents 2 gauss.

Meter Readout:

Direct readout of dc static flux density.

Output:

dc Voltage of 1.0 volt FS is available at output jacks on front panel. Output impedance is approximately 1 kΩ.

Ac Field Measurement:

Ac field response at output jacks is:

100 Gauss Range	dc to 400 Hz
300 Gauss Range	dc to 1,500 Hz
1 kG Range and above	dc to 5,000 Hz

Power Supply:

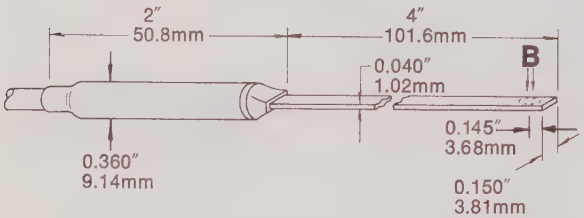
Model 600 — Internal battery (12 V dry battery, Neda 926 — Eveready 732 or equivalent). Model 600A; Ac line operation 115/230 V, 50/60 Hz. Model YB-2062 Power Pack can be supplied separately with Model 600.

Dimensions: **Weight:**

4¼" high; 8¼" wide; 8¼" deep. Shipping 12 lbs., net 9 lbs.

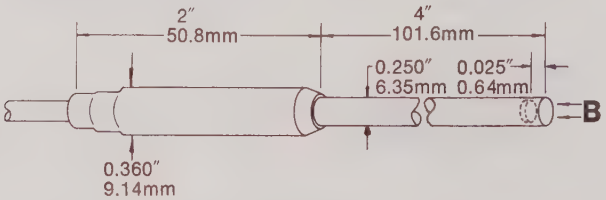
Specifications subject to change without notice.

model STG3-0404
transverse probe



Transverse probe model STG3-0404 is complete with five foot cable and connector. The Hall generator is encapsulated in rigid glass epoxy. This new probe supercedes probe model T-601.

model PAG3-2504
axial probe



Axial probe model PAG3-2504 is complete with five foot cable and connector. The Hall generator is mounted in 0.250" O.D. phenolic tubing. This new probe supercedes probe model A-601.

PROBE SPECIFICATIONS (Below are the two standard probes available for the 600/600A.)

Model	Linearity % of Reading	Active Area	Operating Temperature Range	Temperature Zero	Stability (Max.) Calibrate
STG3-0404	2%/30kG	0.070" dia. nom.	0.0°C to +75°C	±0.09 G/°C	—0.04%/°C
PAG3-2504	2%/30kG	0.030" dia. nom.	0.0°C to +75°C	±0.09 G/°C	—0.04%/°C

See the Instrument Price List for the gaussmeter prices and probe prices.

Special Probes:

Probes can be furnished in various configurations for a wide variety of special applications. Write to F. W. Bell, Inc., Sales Department for details.

Subsidiary, Magnetics & Electronics, Inc

BELL INC.
6120 Hanging Moss Rd.
Orlando, FL 32807
Phone 305/678-6900
TWX: 810-853-3115

PROBE CROSS REFERENCE

MODEL 810

obsoleted model	nearest third generation replacement**	other third generation alternates
T-8001	STB8-0204	STB8-0402, STB8-0404 STE8-0104, STI8-0004
T-8002	STB8-0402	STB8-0404
T-8011	HTB8-0608	HTB8-0618, STB8-0402 STG8-0404
T-8031	STG8-0402	STG8-0404, STG8-0204 HTG8-0608, HTG8-0618
A-8011	SAB8-1808	
		All SAB8 Models All SAE8 Models All HAB8 Models
A-8031	SAG8-1808	All SAG8 Models All HAG8 Models
M-8001	MOE8-2506	
2X-8001	YOB8-1808	All YOB8 Models
3X-8001	ZOB8-3208	All ZOB8 Models
HFT-8000	STR8-0402*	STR8-0404,* STR8-0204* HTR8-0608,* HTR8-0618*
HFA-8000	SAR8-1808*	All SAR8 Models* All HAR8 Models*
HLT-8000	STL8-0402*	All STL8 Models* All STJ8 Models* All STR8 Models* All HTL8 Models* All HTJ8 Models* All HTR8 Models*
HLA-8000	SAN8-1808*	All SAK8 Models* All SAN8 Models* All SAR8 Models* All HAK8 Models* All HAN8 Models* All HAR8 Models*

MODEL 660

obsoleted model	nearest third generation replacement**	other third generation alternates
T-6611	HTB6-0608	HTB6-0618, STB6-0404 STB6-0404
T-6610	STJ6-0402*	STJ6-0404,* STJ6-0204* HTJ6-0608,* HTJ6-0618*
T-6631	STG6-0402	STG6-0404, STG6-0204 HTG6-0608, HTG6-0618
T-6630	STL6-0402*	STL6-0404,* STL6-0204* HTL6-0608,* HTL6-0618*
A-6611	SAB6-1808	All SAB6 Models All SAE6 Models All HAB6 Models
A-6610	SAK6-1808*	All SAK6 Models* All HAK6 Models*
A-6631	SAG6-1808	All SAG6 Models All HAG6 Models
A-6630	SAN6-1808*	All SAN6 Models* All HAN6 Models*
HFT-6600	STR6-0402*	All STR6 Models* All HTR6 Models*
HFA-6600	SAR6-1808*	All SAR6 Models* All HAR6 Models*
HLT-6600	STL6-0402*	All STL6 Models* All STJ6 Models* All STR6 Models* All HTJ6 Models* All HTL6 Models* All HTR6 Models*
HLA-6600	SAN6-1808*	All SAK6 Models* All SAN6 Models* All SAR6 Models* All HAK6 Models* All HAN6 Models* All HAR6 Models*

*10X probe sensitivity is one-tenth standard probe (1X) sensitivity.

**Probes listed are nearest third generation types and are not exact physical/electrical replacements. Consult third generation probe data sheet for complete specifications.

PROBE CROSS REFERENCE

MODEL 620/640

obsoleted model	nearest third generation replacement**	other third generation alternates
T-6001	STB4-0204	STB4-0402, STB4-0404 STE4-0104, STI4-0004
T-6002	STB4-0402	STB4-0404
T-6011	HTB4-0608	HTB4-0618, STB4-0402 STB4-0404
T-6010	STJ4-0402*	STJ4-0404*, STJ4-0204* HTJ4-0608*, HTJ4-0618*
T-6031	STG4-0402	STG4-0404, STG4-0204 HTG4-0608, HTG4-0618
T-6030	STL4-0402*	STL4-0404*, STL4-0204* HTL4-0608*, HTL4-0618*
A-6011	SAB4-1808	All HAB4 Models All SAB4 Models All SAE4 Models
A-6010	SAK4-1802*	All SAK4 Models* All HAK4 Models*
A-6031	SAG4-1808	All SAG4 Models All HAG4 Models
A-6030	SAN4-1808*	All SAN4 Models* All HAN4 Models*
M-6001	MOE4-2506	
2X-6001	YOB4-1808	All YOB4 Models
3X-6001	ZOB4-3208	All ZOB4 Models
HFT-6000	STR4-0402*	STR4-0404*, STR4-0204* HTR4-0608*, HTR4-0618*
HFA-6000	SAR4-1808*	All SAR4 Models* All HAR4 Models*
HLT-6000	STL4-0402*	STL4-0404*, STJ4-0204* All HTJ4 Models* All STJ4 Models* All STR4 Models* All HTL4 Models* All HTR4 Models*
HLA-6000	SAN4-1808*	All SAK4 Models* All SAN4 Models* All SAR4 Models* All HAK4 Models* All HAN4 Models* All HAR4 Models*

MODEL 610

obsoleted model	nearest third generation replacement**	other third generation alternates
T-6101	STB1-0204	STB1-0402, STB1-0404 STE1-0104, STI1-0004
T-6102	STB1-0402	STB1-0404
T-6111	HTB1-0608	STB1-0402, STB1-0400 HTB1-0618
T-6131	STG1-0402	HTG1-0618, HTG1-0608 STG1-0404, STG1-0204
A-6111	SAB1-1808	SAB1-1802, SAB1-1818 SAB1-1836, HAB1-2502 HAB1-2508, HAB1-2518 HAB1-2536, SAB1-1202 SAB1-1208, SAB1-1218 SAB1-1236, SAE1-0802 SAE1-0808, SAE1-0818 SAE1-0602, SAE1-0608 SAE1-0618, SAE1-0636
A-6131	SAG1-1808	SAG1-1802, SAG1-1818 SAG1-1836, HAG1-2502 HAG1-2508, HAG1-2518 HAG1-2536
M-6101	MOE1-2506	

*10X probe sensitivity is one-tenth standard probe (1X) sensitivity.

**Probes listed are nearest third generation types and are not exact physical/electrical replacements. Consult third generation probe data sheet for complete specifications.

Subsidiary,
Magnetics & Electronics, Inc

BELL INC.
6120 Hanging Moss Rd.
Orlando, FL 32807
Phone 305 275 6900
TWX: 810-853-3115

F.W. BELL

PRODUCT BULLETIN

Subject: REFERENCE MAGNETS **No.** 106

A series of permanent-magnet type calibration magnets are available from F. W. Bell, Inc. These magnets are designed expressly for the calibration of Hall effect sensing elements. Each magnet is marked with the flux density in gauss as measured with a F. W. Bell Hall generator. A National Bureau of Standards (NBS) Calibration Certificate is included with each new reference magnet.

MODEL NUMBER	FLUX DENSITY *	CALIBRATION ACCURACY	GAP DIMENSIONS
		AXIAL	
VA-067A	300 gauss	±1%	0.312" diameter
VA-068A	100 gauss	±2%	0.312" diameter
		TRANSVERSE	
VA-070A	300 gauss	±1%	0.062" x 0.500"
VA-071A	1000 gauss	±1/2%	0.062" x 0.500"
VA-072A	3000 gauss	±1/2%	0.062" x 0.500"
**VB-1839	10000 gauss	±1/2%	0.080" x 0.750"
***VB-1840	14000 gauss	±1/2%	0.080" x 0.750"

* TOLERANCES: +0.0%; -5.0%
** REPLACES OBSOLETE MODEL NUMBER VA-073A
*** REPLACES OBSOLETE MODEL NUMBER VA-074A

All calibration magnets of 3,000 gauss and lower are heavily shielded. The measurement gaps are centrally located in symmetrical structures. They have very low external (stray) fields and are well shielded from the affects of outside magnetic fields. The calibration of these magnets is not affected by exposure to external fields of up to 10% of the calibration value, although the reading may be affected during the period of exposure.

Magnets of 10,000 gauss and higher use a large C-magnet. Because of the relatively small air gap, the external stray field from the C structure is low, although it is higher than from the enclosed type of magnet. The gap opening may be sealed with tape when not in use to prevent metal particles from lodging between the poles due to the high magnetic attraction.

To preserve the calibration accuracy of reference magnets, observe the following normal precautions:

OVER

6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

(a) Keep calibration magnets away from other strong magnets or magnetic fields. Do not allow the calibration magnet to come into contact with other large permanent magnets which could change the value or cause the case of the magnet to become locally magnetized.

(b) Do not drop the magnets or otherwise cause a severe shock on the magnet.

(c) Do not expose the magnets to extreme temperatures.

(d) Prevent particles of magnetic material from becoming lodged in the measurement gap of the magnet. Clean out the gap with double-sided Scotch tape if necessary.

(e) When using C-magnets on an open table, avoid positioning ferrous plates close to the magnet sides. These plates will alter the external flux pattern of the magnet during the measurement.

Since Hall generators are sensitive to the direction of the magnetic field as well as its value, it is necessary to position the Hall probe in the air gap so that the Hall generator's active area is centered in gap's measurement area and orientated for MAXIMUM flux reading on the gaussmeter. The correct calibration flux value will be obtained only when the probe is inserted to the proper depth for maximum output and then rotated for a maximum reading.

Although all F. W. Bell, Inc. reference magnets are stabilized to minimize variations in their flux density values due to metallurgical changes, time, temperature, shock, etc, the magnets should be returned periodically to F. W. Bell, Inc. for a calibration check. Recommended intervals are six months after the initial purchase and annually thereafter. A nominal fee is charged for this service.

Special values of flux density or special accuracies are available. Consult the factory for details.

PROBES FOR 110, 120 & 240 GAUSSMETERS

DESCRIPTION

These new probes are precision, solid-state magnetic field sensors designed for use with F. W. Bell model 110, 120, or 240 Gaussmeters. Each probe provides a flux density proportional output for repeatable, high-stability, low noise field measurements. These probes are economical, readily-available replacements for the obsolete YA-, T-, and A-series probes. The lower price and improved quality are benefits of new technology and experience.

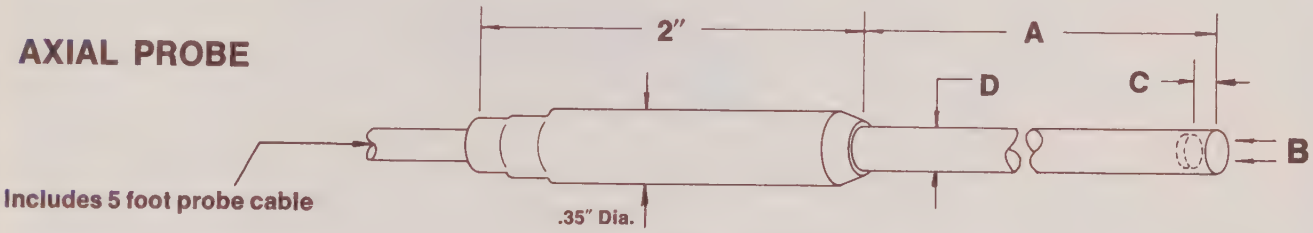
CAUTION! Probes are fragile! Handle with care!

The axial probes feature rugged construction combined with a balanced, light-weight design suitable for manual or fixtured applications.

The transverse probes feature a flexible stem for flux readings in hard-to-get-at places. The thin sensing area is ideal for gap field measurements.

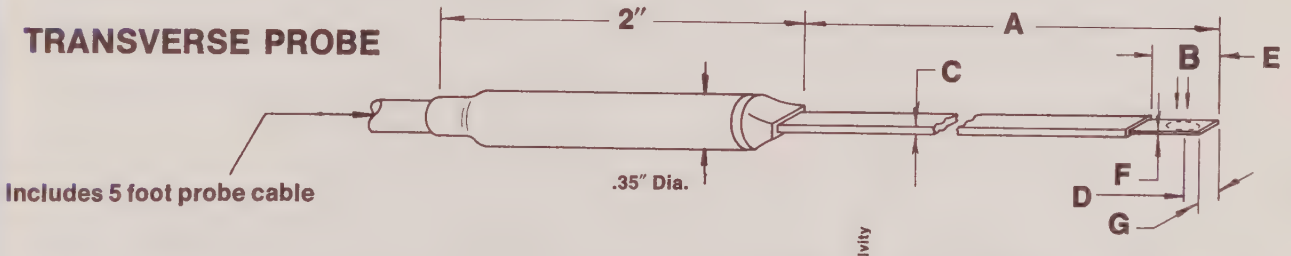
To find the appropriate probe model for your Bell Gaussmeter, refer to the cross-reference chart below. Also check the probe specifications. If you have questions, write or call the F. W. Bell Sales Department or your local representative.

AXIAL PROBE



Model	Price	A	D	C	Stem Material	Linearity % of Reading	Sensitivity	Active Area	Operating Temperature Range	Temperature Zero	Stability (max.) Calibrate
SAE5-1808	$294	8″ ±⅛″	0.180″ +0.002 −0.004	.010″ ±.002	Aluminum	2% to 10 kG	1x	0.030″ dia. nom.	0°C to +75°C	±0.096 Gauss/°C	−0.04% /°C
SAE7-1808						3% to 10 kG					
SAI2-1808											

TRANSVERSE PROBE



Model	Price	A	G	C	D	E	F	Stem Material	Linearity % of Reading	Sensitivity	Active Area	Operating Temperature Range	Temperature Zero	Stability (max.) Calibrate
STE5-0204	$257	4″ ±1/16″	0.135″ (max.)	0.040″ +0.002 −0.009	0.130″ ±0.008	0.375″ ±.063	0.020″ (max.)	flexible rubber	2% to 10 kG	1x	0.070″ dia. nom.	0.0°C to +75°C	Gauss/°C ±0.096	−0.04% /°C
STE7-0204									3% to 10 kG					
STI2-0204														

PROBE CROSS REFERENCE

Gaussmeter Model	New Probe	Configuration	Obsoleted Probes
110	STI2-0204	transverse	T-1101, YA-147
	SAI2-1808	axial	A-1101, YA-148
120	STE5-0204	transverse	T-1201, YA-47
	SAE5-1808	axial	A-1201, YA-48
240	STE7-0204	transverse	T-2401, YA-247
	SAE7-1808	axial	A-2401, YA-248

Specifications subject to change without notice.

Subsidiary,
Magnetics & Electronics, Inc.

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

F.W. BELL INC.

GAUSSMETER
DIFFERENTIAL PROBES

FEATURES

EXCELLENT ABSOLUTE ACCURACY, 1.0% to 30 kG

PROBE LINEARITY MATCHED WITHIN 0.25%

1 PART IN 10^5 RESOLUTION

APPLICATIONS

Field gradient measurement and mapping

Differential field measurements

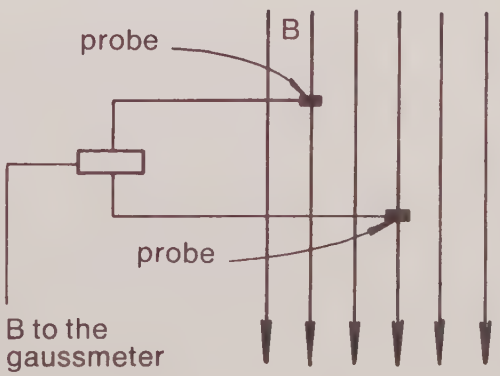
Comparison magnetic testing

Design of coils and solenoids

DESCRIPTION

The differential probe is a two probe device designed for operation with appropriate F.W. Bell gaussmeters. The unit consists of two magnetic field probes and a control module. Probes may be for axial field measurement or for transverse measurements. The control module houses the function switch and the zero and balance controls.

The differential probe is designed to measure an unknown magnetic field differential. It provides a signal proportional to the difference of the magnetic flux densities at each probe active area. Probes may be placed as close as physically possible (a few thousandths of an inch) up to 70" apart.



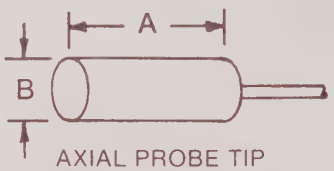
GAUSSMETER DIFFERENTIAL PROBES

SPECIFICATIONS

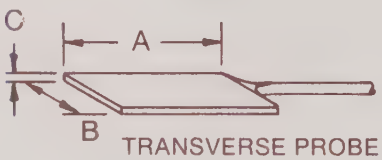
model number	gaussmeter	"A"	"B"	"C"	material	linearity	sensitivity	active area	operating temperature range	temperature zero	stability cal.	matching accuracy
DAP4-1835	620/640	1 ±.03"	.180 ± .005"	N.A	aluminum	1% to 30 kG	10X *	.030" .762mm dia	0.0°C to +75°C	±0.13 Gauss/°C	−.005 %/°C	curve shape matches within 0.25%
DAP8-1835	800 series	25.4 ± 0.8mm	4.57 ± 0.13mm									
DAP1-1835	610/615											
DTP4-0435	620/640	.600 ± .125"	.150 ± .005"	.040 ± .004"	epoxy-fiberglass	1% to 30 kG	10X *	.040" 1.02mm dia	0.0°C to +75°C	±0.13 Gauss/°C	−.005 %/°C	curve shape matches within 0.25%
DTP8-0435	800 series	15.2 ± 3.17mm	3.81 ± 0.13mm	1.02 ± 10mm								
DTP1-0435	610/615											

PRICE $536.00

* 10X probe sensitivity is one-tenth standard probe (1X) sensitivity



AXIAL PROBE TIP



TRANSVERSE PROBE TIP

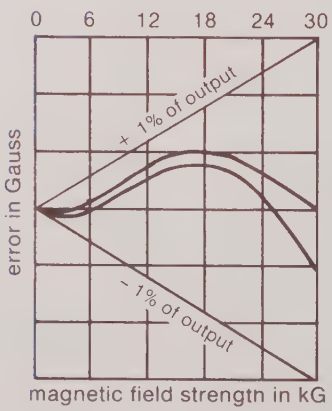
OPERATION

Zero the probes. The 620/640 and 800 series gaussmeters' internal zero control may be switched out (disabled). The 610/615 gaussmeters' internal zero control must be mechanically centered. Select each probe with the mode switch and zero it with the appropriate zero control. The probe should be placed in a zero Gauss chamber. For differential measurements, select the differential mode and place the probes close together in a homogenous field similar in magnitude to the unknown field. Zero the Gaussmeter indication with the balance control.

The instrument is now ready to read the differential measurements. Place the probes at the points of interest and read out the differential field at the Gaussmeter.

LINEARITY CURVES

This is a typical pair of curves for two balanced probes. Note that probe linearity is better than ±1% of reading to 30 kG. Also, when properly balanced, the curves deviate less than ±.25% of the field magnitude. Thus the differential measurement accuracy is better than ±.25% of the field magnitude. The absolute measurement accuracy is better than ±1.0% of reading.



NOTE: 1 Tesla = 10 kGauss

Specifications subject to change without notice

Subsidiary, Magnetics & Electronics, Inc.

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

F.W. BELL

SALES BULLETIN

Subject: CERTIFICATION, DEVIATION CURVES, AND OTHER DOCUMENTS AVAILABLE FOR F. W. BELL PRODUCTS

No. 110

NBS CERTIFICATION

This document certifies that the primary standards used for calibration were calibrated by the National Bureau of Standards (NBS). The document includes the National Bureau of Standards test document number for these primary standards. NBS Certification is priced at $50.00 per unit for individual gaussmeters, single axis Hall generators, or single axis probes, and $75.00 per unit for multiaxis Hall generators and probes. For the certification of the combination of a gaussmeter and probe(s) being ordered or sent back to the factory for repair or recertification the price is $50.00 for the gaussmeter and one (1) probe. Add $25.00 for each additional probe to be calibrated with the gaussmeter. Recertification of reference magnets is $50.00 each.

1) Reference magnets---Customer-owned reference magnets can be sent to the factory for recertification of their flux density. An NBS Calibration Certificate is included with each new reference magnet at no extra charge.
2) Hall Generators---Certification of the magnetic sensitivity at B = 3 kG.
3) Probes---Certification of the reading at B = 3 kG with a factory maintained gaussmeter of known error at 3 kG or with the customer's gaussmeter.
4) Gaussmeters---Certification of the reading at B = 3 kG with a factory maintained probe of known error at 3 kG or with customer's probe.

Note: If the customer plans on using the gaussmeter with a particular probe(s), best results are obtained when gaussmeter and probe(s) are calibrated together.

CERTIFICATE OF CALIBRATION

This document certifies that the equipment has been duly inspected, adjusted, and calibrated to comply with F. W. Bell, Inc. Quality Assurance requirements and to conform to published specifications and is traceable to the NBS. Calibration data is included with the certificate if specified by the customer. The Certificate of Calibration is a $25.00 option available for any F. W. Bell, Inc. product.

CERTIFICATE OF COMPLIANCE

This document certifies that all the parts furnished on an order are in accordance with the specifications in the detailed drawings called for in the purchase order. This is a no-charge option available for any F. W. Bell, Inc. product.

LINEARITY DEVIATION CURVES

These are graphs plotting the deviation of the output, in percent of reading, vs. the appropriate input quantity. This is a $50.00, per input quantity, option ($75.00 for multiaxis Hall generators & probes, or dual section transducers) available for the following products.

-over-

6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

1) Hall Generators---graph plots the deviation of the output voltage vs. the magnetic flux density, B. B = ± 10 kG or ± 30 kG, as applicable. A linearity deviation curve is automatically furnished at no extra charge for the BH-701, BH-704, and any of the BH-900 Series Hall generators.
2) Probes---graph plots the deviation of the output vs. the magnetic flux density, B. B = ± 10 kG or ± 30 kG, as applicable.
3) Transducers---graph plots the deviation of the output vs. the appropriate input quantity (voltage, current, etc.). The range of the input quantity would be zero (0) to rating or zero (0) to a point specified by the customer. Factory approval required before quoting.

TEMPERATURE DEVIATION CURVES

These are graphs plotting the deviation of a specific parameter (see below for choices) vs. temperature. This is a $50.00 per parameter option ($75.00 per parameter for multiaxis Hall generators and gaussmeter probes, or dual section transducers) available for the following products.

1) Hall Generators---the curves are available for Hall output voltage, V_H, (at B = 5 kG or 10 kG, as applicable, unless specified otherwise by the customer) vs. temperature; input resistance, Rin, (at B = 0) vs. temperature; output resistance, Rout, (at B = 0) vs. temperature; or misalignment voltage, Vm, (at B = 0) vs. temperature. The temperature range is -10 degrees C to +80 degrees C. Factory approval is required prior to quoting.
2) Probes---The graph plots the deviation of the output (in gauss) vs. temperature. The temperature range is -10 degrees C to +60 degrees C. B = 5 kG or 10 kG, as applicable unless specified otherwise by the customer. The curve is run on the "bare" Hall generator prior to encapsulation in the probe stem. Factory approval is required prior to quoting.
3) Transducers---the graph plots the deviation of the output (at rated input) vs. temperature for watt, var, voltage, and current transducers. The deviation of the output is expressed in percent of output and the temperature range is -20 degrees C to +70 degrees C.

SPECIAL TESTS

Almost any parameter of any device can be tested and documented for a customer. Contact the factory for approval of test conditions, methods, accuracy, and pricing prior to quoting.

New October 1975

F.W. BELL

PRODUCT BULLETIN

Subject: PROBE SUMMING/SWITCHING BOXES

No. 100

ACCURACY

The accuracy of the summing/switching boxes using probes specifically calibrated for use with the boxes is approximately 5% of the reading at 5 kilogauss, and approximately 10% of the reading at 10 kilogauss. Using probes not specifically calibrated for use with the summing/switching boxes (i.e., our standard third generation probes), the accuracy could be approximately 30% of the reading. In either case, the repeatability of the boxes is 0.2% of the reading. For an additional $50.00 calibration fee F. W. Bell, Inc. will guarantee the accuracy of a summing/switching box to be 2.5% of the reading at 5 kilogauss and 5% of the reading at 10 kilogauss (when used with calibrated probes).

PROBES

Probes calibrated for use with the summing/switching boxes must be assigned special model numbers. If probes are ordered at the same time as a summing/switching box, we need to know which of the probes are to be used with the box. They will be assigned the special model numbers and calibrated at no extra charge. If the customer wishes, he may send probes he already owns back to F. W. Bell, Inc. for relabelling and recalibration for use with the boxes. The fee for this is $25.00 per probe. Only the probes with a sensitivity of 1X can be used with the summing/switching boxes.

MODEL NUMBERS & PRICES

The model numbers and prices are:

Model IS-9140 two-probe summing/switching box	@	$357.00 ea.
Model IS-9139 three-probe summing/switching box	@	408.00 ea.
Model IS-9138 four-probe summing/switching box	@	445.00 ea.
Model IS-9137 five-probe summing/switching box	@	485.00 ea.

GAUSSMETERS

At the present time, the summing/switching boxes are available only for use with either our 620 or our 640 gaussmeters.

AVAILABILITY

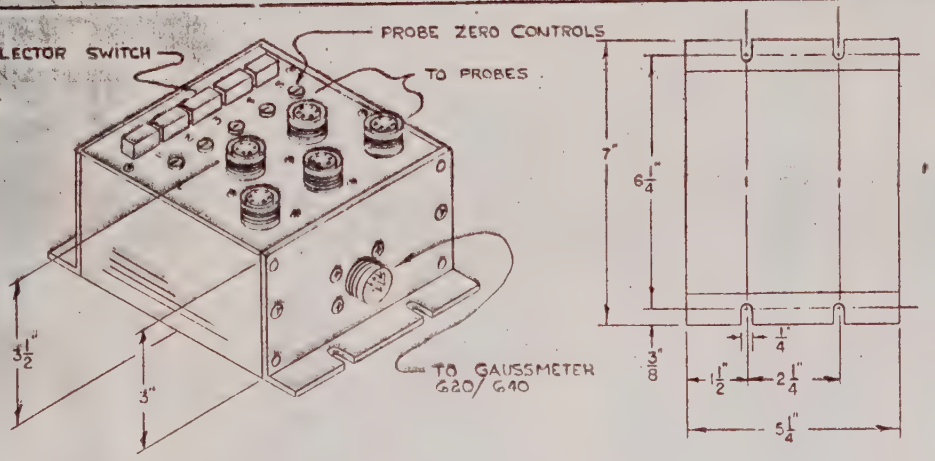
Due to the special nature of the summing/switching boxes, shipment will be approximately three (3) months after receipt of order.

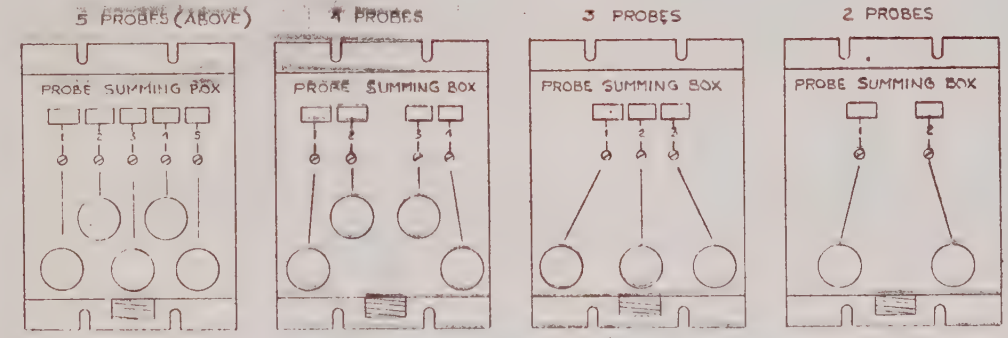
-over-

REVISION 1 MARCH 1980

6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

LTR	ECO	DESCRIPTION	BY/DATE	APR
A	1745	ADD NOTE "1, REF 6	7-22-74	
B	1837	ADD NOTE "2, REF. 7	7-15-75	





GENERAL DESCRIPTION

The summing box is designed to be used with a G20 or G40 Gaussmeter and performs the operation of summing the outputs of from 2 to 5 magnetic field probes. By pushing the buttons of the selector switch the output of any one or the sum of any combination of probe outputs may be read.

OPERATING INSTRUCTIONS

1. Connect probes to the front panel connectors and the Gaussmeter (G20/G40) to the side connector.
2. TO ZERO:
   A. Shield the probes from all stray magnetic fields.
   B. With "All push button switches out" use the zero controls on the Gaussmeter to null out the instrument offsets.
   C. Use the trim pots on the summing box and zero each probe's offset individually to the 1 Gauss range.

NOTES:
1. One Interconnection Cable (6) (Summing Box to Gaussmeter) Included With Each Summing Box - 10FT Length Standard.
2. If Full Complement Of Probes Are Not Used, Probe Simulator (7) Must Be Used In Place Of Probe.

7	REF	YA-2550	PROBE SIMULATOR	ALL
6	REF	YA-2447-( )	ASSY, INTERCONNECTION CABLE	ALL
5	REF	UC-2983	SCHEMATIC, 2 PROBE, MOD. IS-9140	004
4	REF	UC-2982	SCHEMATIC, 3 PROBE, MOD. IS-9139	003
3	REF	UC-2981	SCHEMATIC, 4 PROBE, MOD. IS-9138	002
2	REF	UC-2979	SCHEMATIC, 5 PROBE, MOD. IS-9137	001
1	REF	YB-2478	ASS'Y DRAWING	ALL
REF	QTY	DRAWING NO	DESCRIPTION	VAR

MATERIAL & FINISH: ~

SCALE: HALF | DRN: 9107.5R-
DEC ± | CKD:
FRAC ± | APR:
ANG ± | APP:

BELL & HOWELL, COLUMBUS, OHIO

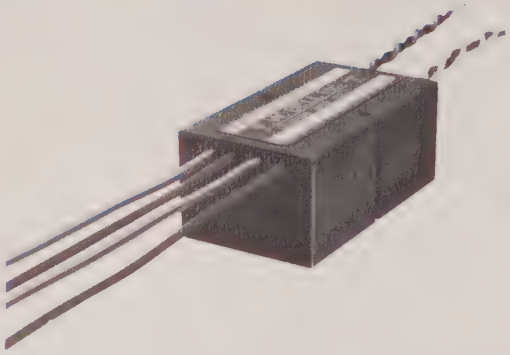
TITLE: SPEC DRAWING 2, 3, 4 & 5 PROBE SUMMING BOX

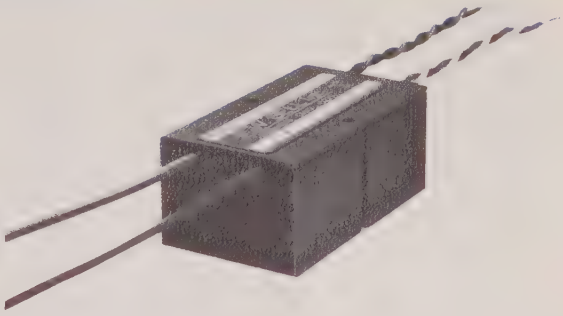
SHT 1 OF 1 | ISSUE DATE | DWG NO UC-2984 | SIZE C

Majestic Industries Inc.
Teterboro, N. J.

INDUSTRIAL WATT TRANSDUCERS

PX-2000 SERIES
PX-4000 SERIES





DESCRIPTION

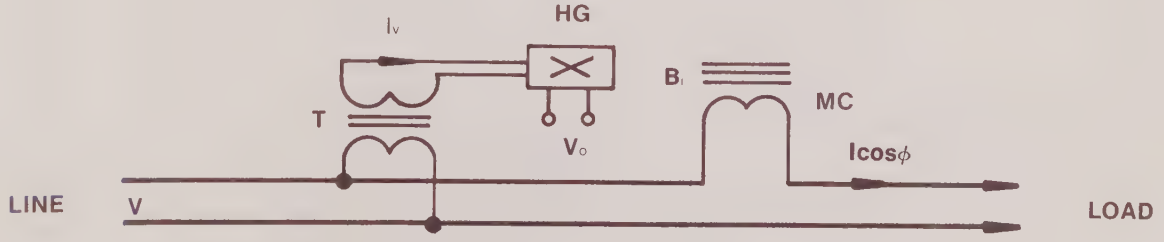
PX-2000 and PX-4000 Series watt transducers are compact, accurate and dependable solid state modules for measurement and control of single phase and 3-phase power at various frequencies in the range from 50 Hz to 10 kHz. The output is a power-proportional dc voltage.

The transducers are fast-responding wide-band devices, capable of computing power with seriously distorted wave form such as occurs in SCR controlled power circuits. The low-frequency PX-2000 Series features models with reference frequencies of 50 Hz, 60 Hz, 180 Hz and 360 Hz. Models of the high frequency PX-4000 Series operate around reference frequencies of 1 kHz and 3 kHz.

All models of the PX-2000 Series have dual current coils, permitting measurement of 3-phase motor power with only one transducer. Two identical models may be combined in conventional wattmeter circuits for 3-phase, 3-wire and 3-phase, 4-wire power.

Each module consists of a potential transformer, a Hall-effect multiplier and corrective circuitry that reduces the influence of low power factor and of ambient temperature fluctuations to acceptable low levels. The output circuit is completely isolated from the input circuits; it can be easily interfaced with panel meters, recorders, amplifiers and power control circuitry.

The lightweight transducer is epoxied in a small nylon case with thru mounting holes and wire leads. This configuration facilitates assembly with associated devices in a suitable enclosure. Simplicity, versatility, high performance and low cost make these modules ideal for incorporation into power and process monitors, limiters and controllers.



POWER MEASUREMENT

Measurement of ac power requires multiplication of voltage, current and power factor: $P = V \times I \times \cos\phi$. The simplest and most reliable way to perform this computation electronically is by means of the Hall generator. This is a magneto-sensitive semiconductor which, when driven by an electric current and exposed to a magnetic field, generates a voltage that is proportional to the product of current and field.

The power measuring circuit consists of only three main components: an isolating potential input transformer (T), a current-sensing magnetic circuit (MC) and a Hall generator (HG), placed in the field of the magnetic circuit.

Here is how it works. Line voltage V, stepped down in the transformer, drives a proportional current I_v thru the Hall generator. Load current $I\cos\phi$ produces a proportional field B_I in the magnetic circuit. The Hall generator, exposed to this field, generates an output voltage proportional to the product of I_v and B_I. It contains an ac component and a dc component. The ac component can be filtered out if necessary. The expression for the dc component is: $V_o = k \times I_v \times B_I = k \times V \times I\cos\phi = k \times P$. The dc output voltage is therefore a measure for the ac power.

PX-2000 SERIES

INDUSTRIAL WATT TRANSDUCERS

Watt modules with dual current coils for accurate measurement of single phase and 3-phase power in wide bands around 50 Hz, 60 Hz, 180 Hz and 360 Hz.

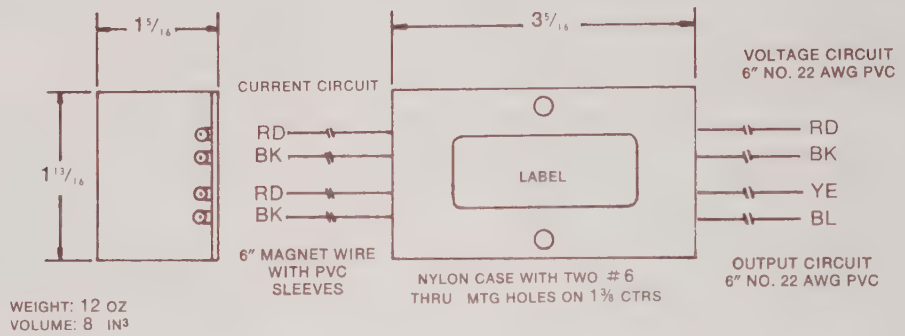


TABLE OF MODELS

MODELS			RATED VOLTAGE, CURRENT AND POWER LEVELS 1)			
Reference Frequencies 60 Hz	180 Hz	360 Hz		Single Phase Series Coils	Single Phase Shunt Coils	Balanced Phase Split Coils
PX-2201B	PX-2201BT	PX-2201BP	120 V	5.0 A, 500 W	10.0 A, 1000 W	6.0 A, 1000 W
PX-2202B	PX-2202BT	PX-2202BP	120 V	10.0 A, 1000 W	20.0 A, 2000 W	12.0 A, 2000 W
PX-2203B	PX-2203BT	PX-2203BP	120 V	0.5 A, 50 W	1.0 A, 100 W	0.6 A, 100 W
PX-2204B	PX-2204BT	PX-2204BP	120 V	1.0 A, 100 W	2.0 A, 200 W	1.2 A, 200 W
PX-2205B	PX-2205BT	PX-2205BP	120 V	2.0 A, 200 W	4.0 A, 400 W	2.4 A, 400 W
Reference Frequency 50 Hz						
PX-2221BL			220 V	5.0 A, 1000 W	10.0 A, 2000 W	6.0 A, 2000 W
PX-2222BL			220 V	10.0 A, 2000 W	20.0 A, 4000 W	12.0 A, 4000 W
PX-2223BL			220 V	0.5 A, 100 W	1.0 A, 200 W	0.6 A, 200 W
PX-2224BL			220 V	1.0 A, 200 W	2.0 A, 400 W	1.2 A, 400 W
PX-2225BL			220 V	2.0 A, 400 W	4.0 A, 800 W	2.4 A, 800 W

PERFORMANCE SPECIFICATIONS

INPUT QUANTITIES AND OPERATING CONDITIONS	PRACTICAL OPERATING RANGES (WITH 0.5% RO ACCURACY)	EXTREME OPERATING RANGES (WITH ADDITIONAL ERRORS)	EXTRA ERROR 2)
Power	0 to 1.5x rated	0 to 2x rated	0.5% RO
current	0 to 1.3x rated	0 to 1.6x rated	0.3% RO
voltage	0 to rated + 15 V	0 to rated + 30 V	0.2% RO
power factor	1 to 0 to −1, lead or lag	PF<0.9 (25 Hz to 500 Hz)	≤5%
Frequency	reference freq. ±20%	25 Hz to 500 Hz (PF>0.9)	0.5%
Waveform	0 to 3% 3rd harmonic	0 to 30% 3rd harmonic	0.2%
Output Load	49 Ω to 51 Ω	45 Ω to 85 Ω	0.1%
Temperature (ambient)	20°C to 30°C	−15°C to 65°C	0.5%

OPERATIONAL CHARACTERISTICS	
Input	
Burden at rated input,	
current circuit	0.01 VA/Hz
voltage circuit	1.0 VA
Output 3)	
Rated Output (RO) across 50 Ω	±55 mV dc ±1%
Source Resistance	≤20 Ω
Linearity vs. Power 4)	≤0.2 % RO
Ripple at Rated Output	110 mV p-p
Response Time to 99%	<50 μs

WITHSTAND CAPABILITIES	
Non-operating ambient	−40°C to 100°C
Current overload, continuous	2x rated
Current surge, 1 second/hour	50x rated
Voltage overload, continuous	rated +40V
Dielectric test voltage,	
between input circuits, inputs to output and all circuits to mtg. surface	1500 V rms, 60 Hz, 1 min
Output short circuit	no damage
Output open circuit	no damage

Notes:

1. The rated power is applied at rated voltage and reference frequency for calibration to the rated output of 55 mV dc across 50 Ω. The rated voltage and current must be compatible with the rated levels of the measured power circuit (or its potential and current transformer secondaries):
2. The overall accuracy is the sum of any applicable extra errors and the 0.5% rated accuracy.
3. The output polarity reverses upon reversal of the energy flow in the measured power circuit or when a cross-over is made in either the voltage input or the current inputs to the transducer.
4. With all operating conditions and input quantities, except current, held constant.

General Monitoring and control of electrical energy and of many electrically powered industrial operations and processes can be greatly improved or simplified by sensing the power level. What is happening at a motor shaft usually reflects accurately and immediately on the power drawn by the motor. The PX-2000 Series watt modules, converting the ac power level into a proportional dc voltage, provide the means for a convenient "handle" on load peaks, machine tool efficiency, process performance and product quality.

Examples Power level input to load management controllers; power level recording in production and life-testing of appliances; monitoring drill bit dulling or breakage in multiple spindle machines; sensing liquid viscosity or sludge consistency in stirring and mixing operations; measuring and controlling the temperature in furnaces; controlling mechanical operations such as machining, stamping, pressing, crushing, grinding, buffing, etc.; monitoring and controlling low frequency induction heating processes.

Power Circuits One or two 120 V modules can easily be hooked up to various power circuits as illustrated in the typical wiring diagrams. The 220 V modules can be hooked up in a similar manner to any 50 Hz or 60 Hz power circuits with standard voltages in the 200 V to 240 V range. Balanced loads, such as most 3-phase motors, require only one module as shown in figure 3.

Input Circuits Proper phase polarity must be observed to insure correct operation of the transducer (see color coding of the transducer leads and phase markings on potential and current transformers). Potential and current transformers, as shown in figure 4, are required when voltage and current levels of the power circuit exceed the rated transducer input levels. An inexpensive method to adapt a 120 V module to 480 V 3-phase is suggested in figure 3. A 220 V module can be adapted to 380 V 3-phase in similar fashion by means of two 18kΩ, 1 W series dropping resistors. With this method, the measurement accuracy is on the order of ±5%.

Output Circuit The unfiltered output voltage can be fed directly to a 50 mV dc moving coil meter or a 100 mV dc digital meter thru a suitable calibration control. When the output is fed into ac-sensitive circuitry, a smoothing filter must be installed to remove the ripple component from the output signal. The RC filter shown in figure 3 reduces the ripple to less than 1%. The output sensitivities of two modules, used for measurement of unbalanced 3-phase power, should be equalized by means of a balancing network as illustrated in figures 4 and 5.

Application Assistance Many power measurement and control problems call for unique solutions. Take advantage of our expertise in the field of power measurement, and consult us for assistance in your particular power control application.

TYPICAL WIRING DIAGRAMS

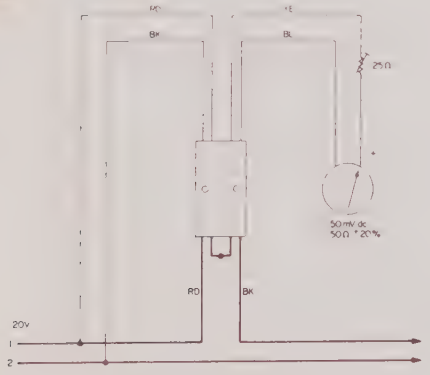


Fig. 1 Single Phase (Series Coils)

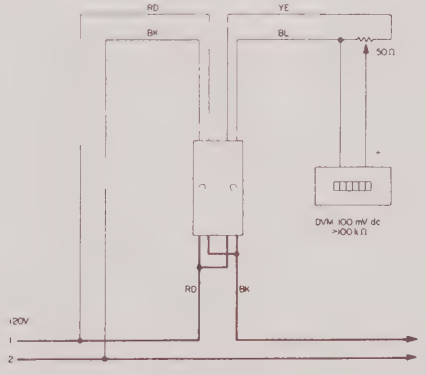


Fig. 2 Single Phase (Shunt Coils)

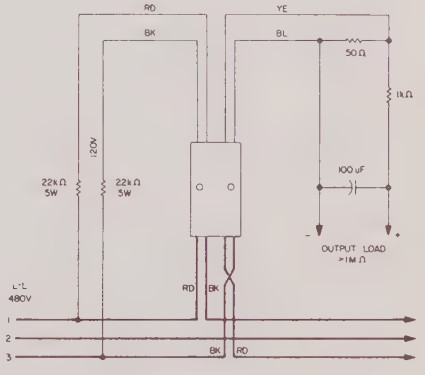


Fig. 3 Balanced 3-Phase (Split Coils)

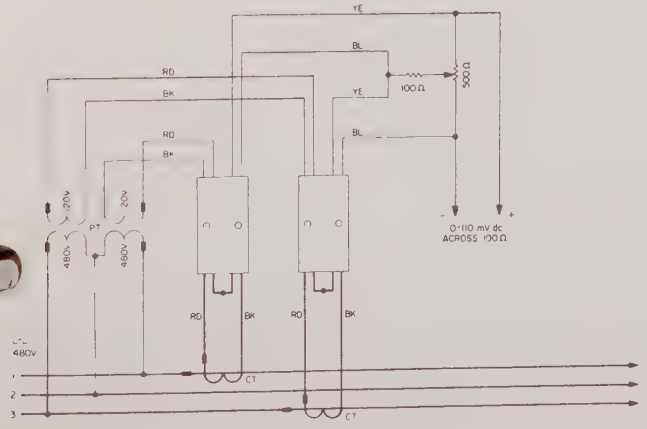


Fig. 4 Unbalanced 3-Phase, 3-Wire (2-Element Wattmeter)

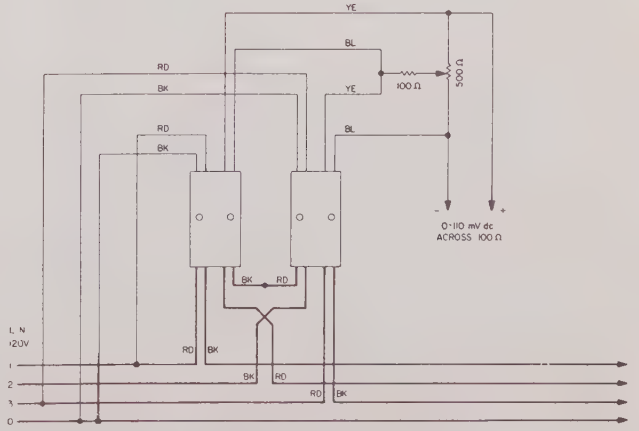


Fig. 5 Unbalanced 3-Phase 4-wire (2½-Element Wattmeter)

PX-4000 SERIES

INDUSTRIAL WATT TRANSDUCERS

Watt modules with single or dual current coil for single phase power measurement in the frequency ranges 500 Hz–3kHz and 500 Hz–10 kHz.

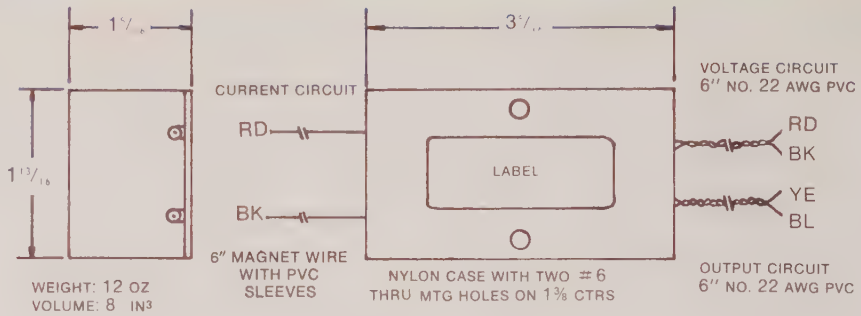


TABLE OF MODELS

MODELS	REFERENCE FREQUENCY	OPERATING RANGE	RATED VOLTAGE	CURRENT COIL	RATED CURRENT AND POWER LEVELS 1)
PX-4111C	1 kHz	500 Hz- 3 kHz	220 V	single	5 A rms, 10 A peak, 1000 W
PX-4121C	3 kHz	500 Hz-10 kHz	220 V	single	5 A rms, 10 A peak, 1000 W
PX-4221C	3 kHz	500 Hz-10 kHz	220 V	series	5 A rms, 10 A peak, 1000 W
				shunt	10 A rms, 20 A peak, 2000 W

PERFORMANCE SPECIFICATIONS

INPUT QUANTITIES AND OPERATING CONDITIONS	PRACTICAL OPERATING RANGES (WITH 0.5% RO ACCURACY)	EXTREME OPERATING RANGES (WITH ADDITIONAL ERRORS)	EXTRA ERROR 2)
Power	0 to 1.5x rated	0 to 2x rated	0.5% RO
current, rms	0 to 1.4x rated	0 to 1.5x rated	0.3% RO
current, peak	0 to rated	0 to 1.5x rated	−10%
voltage, rms	0 to 275 V	0 to 300 V	0.2% RO
power factor	±1 to 0, lead or lag	PF<0.9 (total freq. range)	0.3%/kHz
Frequency 3)	Reference freq. ±20%	Total freq. range (PF>0.9)	0.1%/kHz
Waveform	0 to 3% 3rd harmonic	0 to 30% 3rd harmonic	0.3%
Output Load	49 Ω to 51 Ω	45 Ω to 85 Ω	0.1%
Temperature (ambient)	24°C to 26°C	O°C to 50°C	0.5%

OPERATIONAL CHARACTERISTICS	
Burden, at Rated Input,	
current circuit	3 VA/kHz
voltage circuit	1 VA
Rated Output (RO) across 50 Ω	≥±27 mV dc
Source Resistance, approx.	3 Ω
Linearity vs. Power	≤0.2% RO
Ripple at Rated Output	≥54 mV p-p
Response Time to 99%	<5 μs

WITHSTAND CAPABILITIES	
Non-operating ambient	−40°C to 100°C
Current overload, continuous	2x rated
Voltage overload, continuous	300 V
Dielectric Test Voltage, between input circuits, inputs to output and all circuits to mtg. surface	1500 V rms, 60 Hz, 1 min
Output short or open circuit	no damage

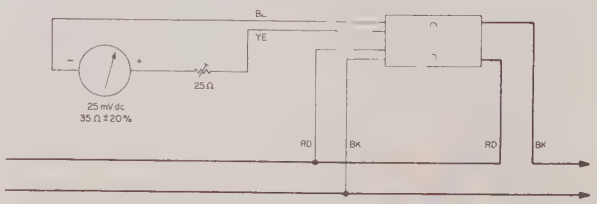
Notes: 1. Rated output at rated power level, all models: ≥27 mV dc across 50 Ω.
2. The overall accuracy is the sum of 0.5% and any applicable extra errors.
3. **Caution:** Do not test these transducers at 60 Hz. Continuous operation below 500 Hz may be destructive.

APPLICATION

PX-4000 Series transducers are primarily intended for supervision and control of high frequency power systems such as used in induction heating processes. The modules can be wired directly to the power circuit as shown in the wiring diagram, provided the permissible voltage and current limits are not exceeded. The output can be fed directly to a 25 mV dc, 35Ω panel meter, thru a suitable calibration resistor. Since the output has a high ripple content, a smoothing filter must be used when feeding the output into ac-sensitive instrumentation. Consult the factory for additional assistance in your particular application.

Specifications subject to change without notice.

TYPICAL WIRING DIAGRAM



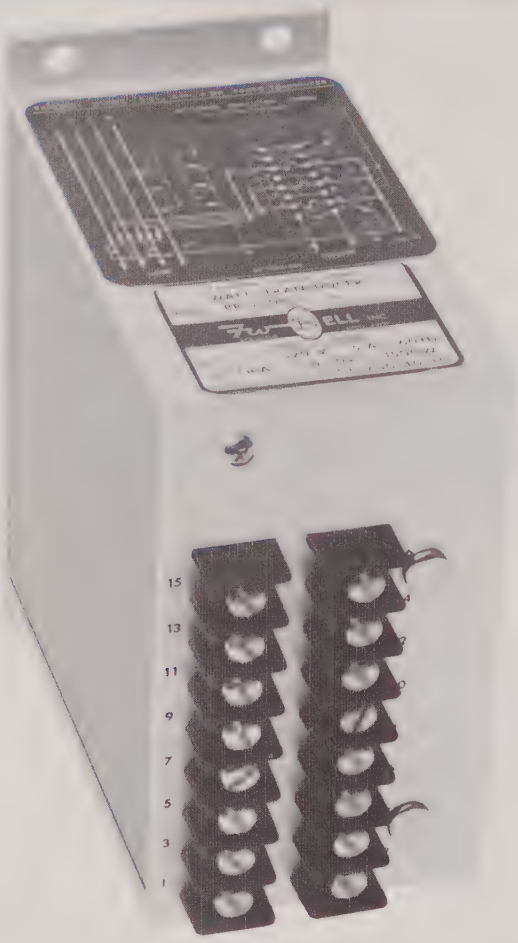
Subsidiary.
Magnetics & Electronics, Inc

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

F.W. BELL INC.

WATT & VAR TRANSDUCERS

R-2000 SERIES



RATED ACCURACY 0.5%:
utility tested and approved

EXCEPTIONAL CHARACTERISTICS:
linearity, stability, temperature

HIGH RELIABILITY:
proven by life testing in process

EXCELLENT WITHSTAND CAPABILITIES:
exceeding proposed IEEE standard

HIGH DENSITY INSTALLATION:
standard case width only 3″

DESCRIPTION

R-2000 power transducers are continuous, direct phasor-multiplication devices. They utilize the Hall-effect to provide an isolated, low ripple dc output that is accurately proportional to active or reactive power. The units are calibrated to within 0.01% of rated output with a low distortion power input at rated level. The 0.05% accurate calibration standards are traceable to the NBS.

The transducers are designed for high accuracy and outstanding reliability. Their high-grade components are submitted to a thorough incoming inspection. The subassemblies and final assemblies are tested in manufacturing and the completed transducers undergo a rigorous quality assurance check. Life testing is continually in process at F.W. Bell, to insure permanent reliability.

The surge withstand capability of the R-2000 power transducers exceeds the minimum test levels proposed by the IEEE. To serve the export market, the units are designed to withstand a dielectric test of 2000 V rms, as required by the electric utilities in Europe.

The main components of the R-2000 power transducers are mounted on a rugged ⅛″ thick PC board which is housed in a 3″ x 5½″ x 6¼″ clear anodized aluminum case. This case has steel side panels that can be easily removed for inspection of components, circuitry and workmanship.

The case dimensions meet the proposed IEEE standard for transducer enclosures. Length and height are identical to those of the R-2000 current and voltage transducers, permitting easy-to-trace wiring in one plane.

The series includes 1-element, single phase models and 1½-, 2-, 2½- and 3-element, 3-phase models for active and reactive power measurement. A wiring diagram is affixed to each case and complete instructions for mounting, wiring, inspection and calibration are included with each transducer shipment.

NEW JULY, 1973 Printed in USA NUMBER 60801

OUTSTANDING FEATURES

NEW Ultra-linear, very stable Hall generator • Linearity error less than 0.1% • Temperature coefficient less than 0.03%/°C.*

NEW Unique, small magnetic circuit • CT burden only 0.4 VA • Excellent physical stability and magnetic field linearity • Composed of special F laminations • Exclusively designed for Hall effect multipliers.**

NEW Individual magnetic shielding of each multiplying element • Reduces external field effects • Permits compact assembly of multi-element transducers without danger of element interaction.

NEW Beefed-up input transformers • Lower winding resistance, reducing thermal effects • Reinforced insulation, withstanding 2 kV rms hipot and 3 kV peak spikes.

NOT NEW (but proven to be very effective) **Multipliers embedded in thermally conductive potting compound** • Reduces thermal gradients • Enhances stability and linearity.

*Designed and manufactured by F.W. Bell, Inc., the world's leading manufacturer of Hall generators.

**Designed in cooperation with and manufactured by The Arnold Engineering Co., specialists in magnetic materials.

NEW Novel amplifier circuit • Using very high gain, low drift IC • Operates at 19 V supply • Provides linear output up to 1.5 mA into 0 to 10 kΩ (or 1 mA into 0 to 15 kΩ).

NEW Two mutually independent thermistor networks • Allows near-straight-line compensation within ±0.01%/°C in the range from −20°C to 70°C (a wider compensated range than offered by any other transducer manufacturer).

An additional thermistor network in var transducers • Corrects both amplitude and phase errors caused by temperature fluctuations.

NEW Individual phase and balance controls on each multiplying element • Factory adjusted to reduce phase and balance errors within 0.02%.

NEW All major components mounted on one sturdy ⅛″ thick PC board • Easily accessible in a case with slide-in panels.

NOT NEW (but appreciated by all burden conscious utilities) **Extra set of terminals for external amplifier power** • Standard option on all models.

WHY UTILIZE THE HALL-EFFECT?

R-2000 watt and var transducers are, just as the S-2000 transducers which they replace, **Hall-effect** power computing devices. F.W. Bell continues to utilize the Hall-effect in its new power transducers for a number of very good reasons. In the first place: the Hall-effect transducer is the only solid-state power measuring device in which the power computation ($P = V \times I \times \cos\phi$) is performed by just **one** semiconductor, the Hall generator. This tiny, but sturdy 4-terminal device does the complete job instantaneously, continuously and directly. It eliminates the need for squaring circuits, sampling techniques or even separate operating power. Compare this with the **multitude of devices** used in any other type of power transducer to perform the same simple computation. It will be quite obvious that, on a statistical basis alone, the Hall-effect transducer, by virtue of its simplicity, must have superior reliability.

A second good reason for continued use of the Hall-effect is that we at F.W. Bell know the Hall generator **thoroughly.** We are the world's leading manufacturer of Hall generators. We use them in our transducers as well as in our multipliers, current sensors, gaussmeters and related products. And we design and manufacture many of them as end-products, for application by other manufacturers in their products, including transducers. Our Hall generator production program includes thin-film (deposited) as well as bulk (sliced) devices.

In the past 15 years F.W. Bell has developed a know-how, a technology and a sophisticated manufacturing facility which enable us to design and produce Hall generators for even the most exotic applications. These include accurate magnetic field measurements at cryogenic temperatures, at extremely high field levels, at very low field levels and in navigational guidance systems. We now have applied our know-how to develop an **ultra-linear, highly stable Hall generator** with a very low temperature dependence, for use in the new R-2000 power transducers.

And a third good reason for continued use of the Hall-effect is that F.W. Bell is intimately familiar with the anatomy of the Hall-effect multiplier: Its **healthy, stable heart** — the new Hall generator — functions properly only when it is contained in an **equally sound and stable body** — the magnetic circuit. The magnetic circuit commonly consists of a stack of standard F-20 laminations with field windings. This type of core construction does not offer the utmost in physical stability and field linearity. In the R-2000 power transducers, F.W. Bell utilizes a unique, self-aligning core, composed of special F laminations, exclusively designed for use in Hall-effect multipliers. The result: a magnetic circuit of superior quality, matching the new Hall generator perfectly. An extra benefit is offered by its smaller size. This substantially reduces the burden imposed on the CT's to which the R-2000 power transducers are connected, thus enhancing the CT accuracy.

PERFORMANCE

The R-2000 power transducers meet or surpass today's most stringent electric utility requirements. **The 0.5% rated accuracy is maintained with any combination of the realistically rated operating conditions, including:** a 30% current over-range; voltage variation from 75 V to 135 V; unity to zero power factor, with leading or lagging and forward or reversed current; ±1 Hz frequency tolerance; 3rd harmonic distortion up to 3%; output load resistance changes from 0 to 10 kΩ; and an ambient temperature range from 15°C to 35°C (59°F to 95°F).

Beyond these ranges the overall accuracy stays well within 1% at current overloads up to 160% of rated and with voltage variations from 50 V to 150 V; or with ambient temperatures as low as —20°C (—4°F) and as high as 70°C (158°F).

The specifications are summarized below. More detailed information is presented in the R-2000 watt & var transducer manual. The performance specifications are logically grouped and clearly defined. Ambiguous expressions such as "accuracy/linearity" have been avoided and incorrect terminology has been replaced. For example, the transducer is not an indicating instrument and does not have a scale. The term "Full Scale (FS)" was therefore replaced by "Rated Output (RO)", which is the output at rated input of the measured quantity.

With the aid of the manual you will be able **to assess the transducer performance at a glance:** whether it is under tightly controlled lab conditions, under practical operating conditions or in the most hostile environment (under the blazing Texas sun or in the polar Canadian air); whether it is during excessive demands with extreme overload currents or during brown-outs with severely reduced voltages. **No matter how critical the power situation, the R-2000 power transducers will render an accurate account of it.**

SPECIFICATIONS

Ranges of operation with 0.5% rated accuracy

Power, effective range	0 to 1.5x rated
current	0 to 1.3x rated
voltage	75 V to 135 V
power factor (angle)	0° to ± 180°
Frequency (watt transducer)[1]	60 Hz ± 1 Hz
Output load resistance	0 to 10 kΩ
Ambient temperature	15°C to 35°C
Relative humidity	10% to 90%

Operational characteristics

Burden at rated input,	
each current circuit, 60 Hz	≤0.4 VA, PF 0.6
each voltage circuit (watt)	≤1.4 VA, PF 1.0
(var, 60 Hz)	≤3.0 VA, PF 0.6
amplifier power circuit[2]	≤3.0 VA, PF 1.0
Rated Output (RO)	1.0 mA dc
Linearity, effective range	<±0.2% RO
Output ripple, peak to peak	<1% RO
Response time to 99%	≤0.4 s
Drift, one year	≤±0.25% RO
Calibration control range, approx.	±10%
Null control range, approx.	±10%

Influences of extreme operating conditions:

Power, 0 to 2x rated (see current & voltage)	
current, 0 to 1.6x rated	0.3% RO
voltage, 50 V to 150V	0.2% RO
power factor (angle)	none
Frequency, 60 Hz ± 5 Hz (watt xdcr)[1]	0.2%
Output load resistance, 0 to 15 kΩ	0.1%
Ambient temperature, —20°C to 70°C	0.01%/°C
Relative humidity, 5% to 95%	0.3%

Withstand capabilities

Non-operating ambient	—40°C to 100°C
Current overload,continuous	2x rated
Current surge, 1 second/hour	50x rated
Voltage overload, continuous	150 V rms
Dielectric Test Voltage, between independent circuits and all circuits to case	2 kV rms, 60 Hz, 1 min
Transient Test Voltage (SWC), across input circuits, input circuits to case and to output	3 kV crest, 1.3 MHz, 2 s
Test Voltage across output circuit	100 V rms, 2 s
Output short and open circuit	protected

Notes: 1. Var transducers contain a 90° phase shift network which causes a frequency influence of 0.15%/0.1 Hz.

2. In regular models this burden adds to the burden of one voltage circuit; in models with modification X (a standard option) the amplifier operating power is to be supplied separately at 115 V ± 35 V ac.

Physical characteristics

Clear anodized aluminum case 3" x 5½" x 6¼" with four ⅝₂" diam mounting holes on 5¾" x 2" centers. Two barrier type terminal blocks with #8 terminal screws on 7/16" centers.

Net weights of the various types:

1 & 1½ element: 1.6 kg (3 lb, 8 oz); 2 & 2½ element: 2.0 kg (4 lb, 8 oz); 3 element: 2.5 kg (5 lb, 8 oz).

R-2000 SERIES

WATT & VAR TRANSDUCERS

STANDARD 60 Hz MODELS

Rated Output 1 mA dc into 0 to 10 kΩ and ±10% calibration control

Power Circuit	3-Phase Limitation voltage	3-Phase Limitation current	Watt Transducers Rated Inputs	Watt Transducers Model	Watt Transducers Model-X[2]	Var Transducers Rated Inputs	Var Transducers Model	Var Transducers Model-X[2]
single phase	—	—	500 W, 120 V, 5 A	PR-2101S	PR-2101SX	500 VAR, 120 V, 5 A	QR-2101S	QR-2101SX
3-phase, 3-wire	balanced	balanced	1000 W, 120 V, 5 A	PR-2201S	PR-2201SX	1000 VAR, 120 V, 5 A	QR-2201S	QR-2201SX
3-phase, 3-wire	none	none	1000 W, 120 V, 5 A	PR-2301S	PR-2301SX	1000 VAR, 120 V, 5 A	QR-2301S	QR-2301SX
3-phase, 4-wire	balanced	none	1500 W, 120 V, 5 A	PR-2401S	PR-2401SX	1500 VAR, 120 V, 5 A	QR-2401S	QR-2401SX
3-phase, 4-wire	none	none	1500 W, 120 V, 5 A	PR-2501S	PR-2501SX	1500 VAR, 120 V, 5 A	QR-2501S	QR-2501SX

SPECIAL 60 Hz MODELS[1]

Rated Output 1 mA dc into 0 to 10 kΩ and 33% to 110% calibration control

Power Circuit	3-Phase Limitation voltage	3-Phase Limitation current	Watt Transducers Rated Inputs	Watt Transducers Model	Watt Transducers Model-X[2]	Var Transducers Rated Inputs	Var Transducers Model	Var Transducers Model-X[2]
single phase	—	—	500 W, 120 V, 5 A	PR-2101T	PR-2101TX	500 VAR, 120 V, 5 A	QR-2101T	QR-2101TX
3-phase, 3-wire	balanced	balanced	1000 W, 120 V, 5 A	PR-2201T	PR-2201TX	1000 VAR, 120 V, 5 A	QR-2201T	QR-2201TX
3-phase, 3-wire	none	none	1000 W, 120 V, 5 A	PR-2301T	PR-2301TX	1000 VAR, 120 V, 5 A	QR-2301T	QR-2301TX
3-phase, 4-wire	balanced	none	1500 W, 120 V, 5 A	PR-2401T	PR-2401TX	1500 VAR, 120 V, 5 A	QR-2401T	QR-2401TX
3-phase, 4-wire	none	none	1500 W, 120 V, 5 A	PR-2501T	PR-2501TX	1500 VAR, 120 V, 5 A	QR-2501T	QR-2501TX

SPECIAL 50 Hz MODELS[1]

Rated Output 1 mA dc into 0 to 10 kΩ and ±10% calibration control

Power Circuit	3-Phase Limitation voltage	3-Phase Limitation current	Watt Transducers Rated Inputs[3]	Watt Transducers Model	Watt Transducers Model-X[2]	Var Transducers Rated Inputs[3]	Var Transducers Model	Var Transducers Model-X[2]
single phase	—	—	500 W, 100 V, 5 A	PR-2141SL	PR-2141SLX	500 VAR, 100 V, 5 A	QR-2141SL	QR-2141SLX
3-phase, 3-wire	balanced	balanced	1000 W, 100 V, 5 A	PR-2241SL	PR-2241SLX	1000 VAR, 100 V, 5 A	QR-2241SL	QR-2241SLX
3-phase, 3-wire	none	none	1000 W, 100 V, 5 A	PR-2341SL	PR-2341SLX	1000 VAR, 100 V, 5 A	QR-2341SL	QR-2341SLX
3-phase, 4-wire	balanced	none	1500 W, 100 V, 5 A	PR-2441SL	PR-2441SLX	1500 VAR, 100 V, 5 A	QR-2441SL	QR-2441SLX
3-phase, 4-wire	none	none	1500 W, 100 V, 5 A	PR-2541SL	PR-2541SLX	1500 VAR, 100 V, 5 A	QR-2541SL	QR-2541SLX

Rated Output 1 mA dc into 0 to 10 kΩ and ±10% calibration control

Power Circuit	3-Phase Limitation voltage	3-Phase Limitation current	Watt Transducers Rated Inputs[3]	Watt Transducers Model	Watt Transducers Model-X[2]	Var Transducers Rated Inputs[3]	Var Transducers Model	Var Transducers Model-X[2]
single phase	—	—	100 W, 100 V, 1 A	PR-2142SL	PR-2142SLX	100 VAR, 100 V, 1 A	QR-2142SL	QR-2142SLX
3-phase, 3-wire	balanced	balanced	200 W, 100 V, 1 A	PR-2242SL	PR-2242SLX	200 VAR, 100 V, 1 A	QR-2242SL	QR-2242SLX
3-phase, 3-wire	none	none	200 W, 100 V, 1 A	PR-2342SL	PR-2342SLX	200 VAR, 100 V, 1 A	QR-2342SL	QR-2342SLX
3-phase, 4-wire	balanced	none	300 W, 100 V, 1 A	PR-2442SL	PR-2442SLX	300 VAR, 100 V, 1 A	QR-2442SL	QR-2442SLX
3-phase, 4-wire	none	none	300 W, 100 V, 1 A	PR-2542SL	PR-2542SLX	300 VAR, 100 V, 1 A	QR-2542SL	QR-2542SLX

Notes:
(1) All special models comply with the standard specifications except for operating frequency and/or output characteristics, which are as shown above.
(2) Models with modification X need external amplifier power at 115 V ± 35 V ac. Consult the factory for methods to derive this power from a 230 V line.
(3) Models with a rated input of 100 V are for use in measuring systems with a nominal voltage in the range from 100 V to 115 V.

For complete details request Instruction Manuals UD-2951-001 and UD-2951-002.

Specifications subject to change without notice.

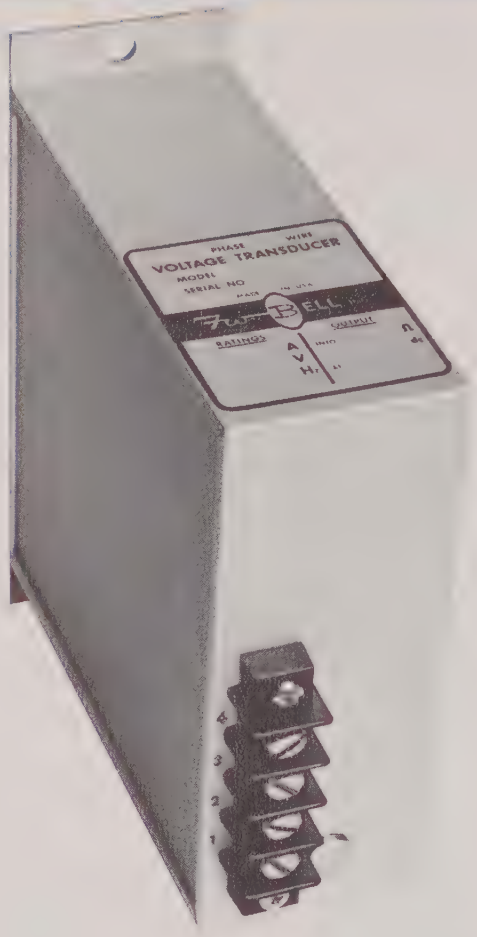
A Subsidiary of
The Arnold Engineering Company

BELL INC.
4949 Freeway Drive East
Columbus, Ohio 43229
Phone: (614) 888-7501
TWX: 810-337-2851

F.W. BELL INC.

CURRENT & VOLTAGE TRANSDUCERS

R-2000 SERIES



RATED ACCURACY 0.5%:
utility tested and approved

EXCEPTIONAL CHARACTERISTICS:
linearity, stability & temperature

HIGH RELIABILITY:
proven by life testing in process

EXCELLENT WITHSTAND CAPABILITIES:
exceeding proposed IEEE standard

HIGH DENSITY INSTALLATION:
space-saving two-section models

DESCRIPTION

R-2000 current and voltage transducers are average-responding rectifying devices. They utilize full-wave rectification to provide an isolated, low ripple dc output that is accurately proportional to ac current or voltage. The units are calibrated to within 0.01% of rated output with a low distortion signal at rated level. The 0.1% accurate calibration standards are traceable to the NBS.

The transducers are designed for high accuracy and outstanding reliability. Their high-grade components are submitted to a thorough incoming inspection. The sub-assemblies and final assemblies are tested in manufacturing and the completed transducers undergo a rigorous quality assurance check. Life testing is continually in process at F.W. Bell, to insure permanent reliability.

The surge withstand capability of the R-2000 current and voltage transducers exceeds the minimum test levels proposed by the IEEE. To serve the export market the units are designed to withstand a dielectric test of 2000 V rms, as required by the electric utilities in Europe.

All components of the R-2000 current and voltage transducers are mounted on one 1/16" thick PC board which is housed in a 2" x 5½" x 6¼" clear anodized aluminum case. This case has steel side panels that can be easily removed for inspection of components, circuitry and workmanship.

The case dimensions meet the proposed IEEE standard for transducer enclosures. Length and height are identical to those of the R-2000 power transducers, permitting easy-to-trace wiring in one plane.

The series includes 32 standard 60 Hz single and two-section models, and 160 special models. Features offered in the special models are rated outputs of 50 mV dc and 10 V dc, 33-110% calibration control and operating frequencies of 50 Hz and 400 Hz. Complete instructions for mounting, wiring, inspection and calibration are included with each transducer shipment.

REVISED APRIL 1980 Printed in USA NUMBER 60802

OUTSTANDING FEATURES

NEW Space, weight and cost saving two-section transducers • Measure two currents, two voltages or a current and a voltage.

NEW Additional rated input levels • Current transducers rated at 1 A, 2 A and 10 A. • Voltage transducers rated at 100 V, 110 V and 120 V.

NEW Beefed-up input transformers • Reinforced insulation, withstands 2 kV rms hipot and 3 kV peak spikes.

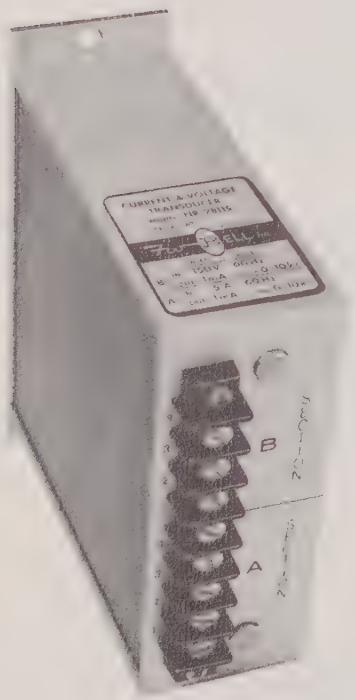
NEW Compensated, low-drift amplifier circuit • Provides linear output up to 1.5 mA into 0 to 10 kΩ (or 1 mA into 0 to 15 kΩ).

NEW Additional amplifier output protection • Protects against extraneous parallel mode voltages up to 100 V rms.

NEW Temperature compensating circuit elements • Allows near-straight-line compensation within ±0.01%/°C in the range from −20° to 70°C (a wider compensated range than offered by any other transducer manufacturer).

NEW All components mounted on one 1/16″ thick G-10 pc board • Easily accessable in a case with slide-in panels.

NEW Barrier terminal blocks of glass-reinforced phenolic • Twice the impact strength of regular phenolic.



WHY USE TWO-SECTION TRANSDUCERS?

As a rule a power circuit needs more than one current or voltage transducer. Single phase circuits usually require measurement of current and voltage. In many 3-phase circuits all three load currents and all three line voltages must be measured. To reduce space, weight and cost of these multiple measurements, F. W. Bell introduces a new concept, the two-section transducer. This transducer consists of two entirely independent measuring circuits, housed in one standard 2″ wide case. For greatest versatility, two-section transducers are made available in three different types: for measurement of two currents, two voltages or a current and a voltage. The advantages of using two-section transducers are considerable. For example, measurement of the three currents and the three voltages in a 3-phase circuit can now be performed with only three two-section units (instead of six single section units). The resulting savings: **50% in space, 33% in weight and 15% in cost.**

INHERENT CHARACTERISTICS

Current and voltage transducers of the R-2000 series are, just as those of most other makes, rectifying devices. Devices of this type have the inherent characteristics of operating over a wide frequency range but being subject to errors caused by frequency variation and waveform distortion. Which of these characteristics is of greatest importance? The answer is obvious. Current and voltage measurements are usually performed at one of the standard line frequencies (50 Hz, 60 Hz or 400 Hz). Whether the same transducer can operate at all three frequencies is immaterial.

What is of importance to the user is to know how the accuracy of the transducer is affected by small frequency variations and by harmonic distortion. Other manufacturers hardly ever mention these influences and merely specify their transducers for operation over a wide frequency range (e.g. 50 Hz to 500 Hz). F. W. Bell feels that the user is better served by its practice, i.e. calibrating and specifying current and voltage transducers for operation at a specific frequency and including pertinent data on the small but significant errors resulting from narrow-band frequency variations and harmonic distortion.

PERFORMANCE

The R-2000 current and voltage transducers meet or surpass today's most stringent electric utility requirements. **The 0.5% rated accuracy is maintained with any combination of the realistically rated operating conditions, including:** a 25% current over-range and a 75 V to 150 V voltage range; ±1 Hz frequency tolerance; 3rd harmonic distortion up to 3%; output load resistance changes from 0 to 10 kΩ; and an ambient temperature range from 15°C to 35°C (59°F to 95°F).

Beyond these ranges the overall accuracy stays well within 1% at current overloads up to 150% of rated and with voltage variations from 0 to 180 V; or with ambient temperatures as low as —20°C (—4°F) and as high as 70°C (158°F).

The specifications are summarized on the next page. More detailed information is presented in the R-2000 current & voltage manuals. The performance specifications are logically grouped and clearly defined. Ambiguous expressions such as "accuracy/linearity" have been avoided and incorrect terminology has been replaced. For example, the transducer is not an indicating instrument and does not have a scale. The term "Full Scale (FS)" was therefore replaced by "Rated Output (RO)", which is the output at rated input of the measured quantity.

With the aid of the manual **you will be able to assess the transducer performance at a glance:** whether it is under tightly controlled lab conditions, under practical operating conditions or in the most hostile environment (under the blazing Texas sun or in the polar Canadian air); whether it is during excessive demands with extreme overload currents or during brown-outs with severely reduced voltages. **No matter how critical the power situation, the R-2000 current and voltage transducers will render an accurate account of it.**

SPECIFICATIONS

Ranges of operation with 0.5% rated accuracy

Current, effective range	0 to 1.25x rated
Voltage, effective range	75 V to 150 V
Frequency	60 Hz ± 1 Hz
Waveform (3rd harmonic)	0 to 1%
Output load resistance	0 to 10 kΩ
Ambient temperature	15°C to 35°C
Relative humidity	10% to 90%

Operational characteristics

Burden at rated input:	
current circuit	≤1.0 VA, PF 1.0
voltage circuit	≤1.5 VA, PF 1.0
Rated Output (RO)	1.0 mA dc
Linearity, in the effective range	<±0.2% RO
Output ripple, peak to peak	<1% RO
Response time to 99%	≤0.3 s
Drift, one year	≤±0.25% RO
Calibration control range, approx.	±10%
Null control	none

Influences of extreme operating conditions

Current, 0 to 1.5x rated	0.3% RO
Voltage, 0 to 180 V	0.5% RO
Frequency, 60 Hz ± 5 Hz	0.2%
Waveform, 0 to 10% 3rd harmonic	2.0%
Output load resistance, 0 to 15 kΩ	0.1%
Ambient temperature, —20°C to 70°C	0.01%/°C
Relative humidity, 5% to 95%	0.2%

Withstand capabilities

Non-operating ambient	—40°C to 100°C
Current overload, continuous	2x rated
Current surge, 1 second/hour	50x rated
Voltage overload, continuous	180 V rms
Dielectric Test Voltage, between independent circuits and all circuits to case	2 kV rms, 60 Hz, 1 min
Transient Test Voltage (SWC), across input, input to case and input to output	3 kV crest, 1.3 MHz, 2 s
Test Voltage across output circuit	100 V rms, 2 s
Output short and open circuit	protected

Physical characteristics

Clear anodized aluminum case 2" x 5½" x 6¼" with two 9/32" diam mounting holes on 5¾" centers.
One barrier type terminal block with #8 terminal screws on 7/16" centers.
Net weight: single section transducer: 0.9 kg (2 lb); two-section transducer: 1.2 kg (2 lb, 11 oz).

STANDARD 60 Hz SINGLE AND TWO-SECTION MODELS

Rated Output 1 mA dc into 0 to 10 kΩ and ±10% calibration control

Rated Input	One Section Model
5 A	IR-2101S
1 A	IR-2102S
2 A	IR-2103S
10 A	IR-2104S
150 V	VR-2101S
120 V	VR-2102S
110 V	VR-2103S
100 V	VR-2104S

Rated Inputs Sect B	Rated Inputs Sect A	Two-Section Model
5 A	5 A	IR-2811S
1 A	1 A	IR-2822S
2 A	2 A	IR-2833S
10 A	10 A	IR-2844S
150 V	150 V	VR-2811S
120 V	120 V	VR-2822S
110 V	110 V	VR-2833S
100 V	100 V	VR-2844S

Rated Inputs Sect B	Rated Inputs Sect A	Two-Section Model
150 V	5 A	NR-2811S
150 V	1 A	NR-2812S
150 V	2 A	NR-2813S
150 V	10 A	NR-2814S
120 V	5 A	NR-2821S
120 V	1 A	NR-2822S
120 V	2 A	NR-2823S
120 V	10 A	NR-2824S

Rated Inputs Sect B	Rated Inputs Sect A	Two-Section Model
110 V	5 A	NR-2831S
110 V	1 A	NR-2832S
110 V	2 A	NR-2833S
110 V	10 A	NR-2834S
100 V	5 A	NR-2841S
100 V	1 A	NR-2842S
100 V	2 A	NR-2843S
100 V	10 A	NR-2844S

CURRENT & VOLTAGE TRANSDUCERS

SPECIAL 60 Hz SINGLE SECTION MODELS

Rated Output: Output Load: Cal Control:	1 mA dc 0 to 10 kΩ 33% to 110%	50 mV dc ≥100 kΩ ±10%	50 mV dc ≥100 kΩ 33% to 110%	10 V dc 1 MΩ ±10%	10 V dc 1 MΩ 33% to 110%
Rated Input	Model	Model	Model	Model	Model
5 A	IR-2101T	IR-2101H	IR-2101K	IR-2101P	IR-2101R
1 A	IR-2102T	IR-2102H	IR-2102K	IR-2102P	IR-2102R
2 A	IR-2103T	IR-2103H	IR-2103K	IR-2103P	IR-2103R
10 A	IR-2104T	IR-2104H	IR-2104K	IR-2104P	IR-2104R
150 V	VR-2101T	VR-2101H	VR-2101K	VR-2101P	VR-2101R
120 V	VR-2102T	VR-2102H	VR-2102K	VR-2102P	VR-2102R
110 V	VR-2103T	VR-2103H	VR-2103K	VR-2103P	VR-2103R
110 V	VR-2104T	VR-2104H	VR-2104K	VR-2104P	VR-2104R

SPECIAL 60 Hz TWO-SECTION MODELS

Rated Output 1 mA dc into 0 to 10 kΩ and 33% to 110% calibration control

Rated Inputs Sect B	Rated Inputs Sect A	Model
5 A	5 A	IR-2811T
1 A	1 A	IR-2822T
2 A	2 A	IR-2833T
10 A	10 A	IR-2844T
150 V	150 V	VR-2811T
120 V	120 V	VR-2822T
110 V	110 V	VR-2833T
100 V	100 V	VR-2844T

Rated Inputs Sect B	Rated Inputs Sect A	Model
150 V	5 A	NR-2811T
150 V	1 A	NR-2812T
150 V	2 A	NR-2813T
150 V	10 A	NR-2814T
120 V	5 A	NR-2821T
120 V	1 A	NR-2822T
120 V	2 A	NR-2823T
120 V	10 A	NR-2824T

Rated Inputs Sect B	Rated Inputs Sect A	Model
110 V	5 A	NR-2831T
110 V	1 A	NR-2832T
110 V	2 A	NR-2833T
110 V	10 A	NR-2834T
100 V	5 A	NR-2841T
100 V	1 A	NR-2842T
100 V	2 A	NR-2843T
100 V	10 A	NR-2844T

SPECIAL 50 Hz SINGLE SECTION MODELS

Rated Output: Output Load: Cal Control:	1 mA dc 0 to 10 kΩ ±10%	1 mA dc 0 to 10 kΩ 33% to 110%	50 mV dc ≥100 kΩ ±10%	50 mV dc ≥100 kΩ 33% to 110%	10 V dc 1 MΩ ±10%	10 V dc 1 MΩ 33% to 110%
Rated Input	Model	Model	Model	Model	Model	Model
5 A	IR-2101SL	IR-2101TL	IR-2101HL	IR-2101KL	IR-2101PL	IR-2101RL
1 A	IR-2102SL	IR-2102TL	IR-2102HL	IR-2102KL	IR-2102PL	IR-2102RL
2 A	IR-2103SL	IR-2103TL	IR-2103HL	IR-2103KL	IR-2103PL	IR-2103RL
10 A	IR-2104SL	IR-2104TL	IR-2104HL	IR-2104KL	IR-2104PL	IR-2104RL
150 V	VR-2101SL	VR-2101TL	VR-2101HL	VR-2101KL	VR-2101PL	VR-2101RL
120 V	VR-2102SL	VR-2102TL	VR-2102HL	VR-2102KL	VR-2102PL	VR-2102RL
110 V	VR-2103SL	VR-2103TL	VR-2103HL	VR-2103KL	VR-2103PL	VR-2103RL
100 V	VR-2104SL	VR-2104TL	VR-2104HL	VR-2104KL	VR-2104PL	VR-2104RL

SPECIAL 400 Hz SINGLE SECTION MODELS

Rated Output: Output Load: Cal Control:	1 mA dc 0 to 10 kΩ ±10%	1 mA dc 0 to 10 kΩ 33% to 110%	50 mV dc ≥100 kΩ ±10%	50 mV dc ≥100 kΩ 33% to 110%	10 V dc 1 MΩ ±10%	10 V dc 1 MΩ 33% to 110%
Rated Input	Model	Model	Model	Model	Model	Model
5 A	IR-2101SQ	IR-2101TQ	IR-2101HQ	IR-2101KQ	IR-2101PQ	IR-2101RQ
1 A	IR-2102SQ	IR-2102TQ	IR-2102HQ	IR-2102KQ	IR-2102PQ	IR-2102RQ
2 A	IR-2103SQ	IR-2103TQ	IR-2103HQ	IR-2103KQ	IR-2103PQ	IR-2103RQ
10 A	IR-2104SQ	IR-2104TQ	IR-2104HQ	IR-2104KQ	IR-2104PQ	IR-2104RQ
150 V	VR-2101SQ	VR-2101TQ	VR-2101HQ	VR-2101KQ	VR-2101PQ	VR-2101RQ
120 V	VR-2102SQ	VR-2102TQ	VR-2102HQ	VR-2102KQ	VR-2102PQ	VR-2102RQ
110 V	VR-2103SQ	VR-2103TQ	VR-2103HQ	VR-2103KQ	VR-2103PQ	VR-2103RQ
100 V	VR-2104SQ	VR-2104TQ	VR-2104HQ	VR-2104KQ	VR-2104PQ	VR-2104RQ

Note: All special models comply with the standard specifications except for operating frequency and/or output characteristics, which are as shown above.

For complete details request Instruction Sheets UC-2907-001 and UC-2907-002.

Specifications subject to change without notice.

Subsidiary.
Magnetics & Electronics, Inc

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

F.W. BELL INC.

TRANSDUCER PRICE LIST

Industrial Watt Transducers

120 V 50-70 Hz

PX-2201B	$81
PX-2202B	81
PX-2203B	81
PX-2204B	81
PX-2205B	81

120 V 150-210 Hz

PX-2201BT	$81
PX-2202BT	81
PX-2203BT	81
PX-2204BT	81
PX-2205BT	81

120 V 300-420 Hz

PX-2201BP	$81
PX-2202BP	81
PX-2203BP	81
PX-2204BP	81
PX-2205BP	81

220 V 1-10 kHz

PX-4111C	$94
PX-4121C	94
PX-4221C	94

220 V 50-60 Hz

PX-2221BL	$94
PX-2222BL	94
PX-2223BL	94
PX-2224BL	94
PX-2225BL	94

Power System Transducers Watt & Var

60 Hz

PR-2101S	$242
PR-2101SX	242
PR-2201S	242
PR-2201SX	242
PR-2301S	311
PR-2301SX	311
PR-2401S	311
PR-2401SX	311
PR-2501S	366
PR-2501SX	366
PR-2101T	$246
PR-2101TX	246
PR-2201T	246
PR-2201TX	246
PR-2301T	317
PR-2301TX	317
PR-2401T	317
PR-2401TX	317
PR-2501T	374
PR-2501TX	374
QR-2101S	$272
QR-2101SX	272
QR-2201S	272
QR-2201SX	272
QR-2301S	348
QR-2301SX	348
QR-2401S	348
QR-2401SX	348
QR-2501S	423
QR-2501SX	423
QR-2101T	$278
QR-2101TX	278
QR-2201T	278
QR-2201TX	278
QR-2301T	356
QR-2301TX	356
QR-2401T	356
QR-2401TX	356
QR-2501T	431
QR-2501TX	431

50 Hz

PR-2141SL	$253
PR-2141SLX	253
PR-2241SL	253
PR-2241SLX	253
PR-2341SL	321
PR-2341SLX	321
PR-2441SL	321
PR-2441SLX	321
PR-2541SL	381
PR-2541SLX	381
PR-2142SL	$260
PR-2142SLX	260
PR-2242SL	260
PR-2242SLX	260
PR-2342SL	329
PR-2342SLX	329
PR-2442SL	329
PR-2442SLX	329
PR-2542SL	386
PR-2542SLX	386
QR-2141SL	$285
QR-2141SLX	285
QR-2241SL	285
QR-2241SLX	285
QR-2341SL	360
QR-2341SLX	360
QR-2441SL	360
QR-2441SLX	360
QR-2541SL	438
QR-2541SLX	438
QR-2142SL	$291
QR-2142SLX	291
QR-2242SL	291
QR-2242SLX	291
QR-2342SL	367
QR-2342SLX	367
QR-2442SL	367
QR-2442SLX	367
QR-2542SL	442
QR-2542SLX	442

400 Hz

PR-2101SQ	$278
PR-2101SQX	278
PR-2201SQ	278
PR-2201SQX	278
PR-2301SQ	348
PR-2301SQX	348
PR-2401SQ	348
PR-2401SQX	348
PR-2501SQ	405
PR-2501SQX	405
QR-2101SQ	$311
QR-2101SQX	311
QR-2201SQ	311
QR-2201SQX	311
QR-2301SQ	386
QR-2301SQX	386
QR-2401SQ	386
QR-2401SQX	386
QR-2501SQ	462
QR-2501SQX	462

TRANSDUCER PRICE LIST

Power System Transducers
Current & Voltage
60 Hz

IR-2101H $ 81	IR-2102H $ 85	IR-2103H $ 85	IR-2104H $ 85
IR-2101K 84	IR-2102K 92	IR-2103K 92	IR-2104K 92
IR-2101P 81	IR-2102P 84	IR-2103P 84	IR-2104P 84
IR-2101R 84	IR-2102R 91	IR-2103R 91	IR-2104R 91
IR-2101S 76	IR-2102S 81	IR-2103S 81	IR-2104S 81
IR-2101T 81	IR-2102T 85	IR-2103T 85	IR-2104T 85
IR-2811S 116	IR-2822S 123	IR-2833S 123	IR-2844S 123
IR-2811T 121	IR-2822T 130	IR-2833T 130	IR-2844T 130
NR-2811S $116	NR-2812S $123	NR-2813S $123	NR-2814S $123
NR-2811T 121	NR-2812T 130	NR-2813T 130	NR-2814T 130
NR-2821S 123	NR-2822S 123	NR-2823S 123	NR-2824S 123
NR-2821T 119	NR-2822T 130	NR-2823T 130	NR-2824T 130
NR-2831S 123	NR-2832S 123	NR-2833S 123	NR-2834S 123
NR-2831T 130	NR-2832T 130	NR-2833T 130	NR-2834T 130
NR-2841S 123	NR-2842S 123	NR-2843S 123	NR-2844S 123
NR-2841T 130	NR-2842T 130	NR-2843T 130	NR-2844T 130
VR-2101H $ 81	VR-2102H $ 85	VR-2103H $ 85	VR-2104H $ 85
VR-2101K 85	VR-2102K 92	VR-2103K 92	VR-2104K 92
VR-2101P 81	VR-2102P 85	VR-2103P 85	VR-2104P 85
VR-2101R 85	VR-2102R 92	VR-2103R 92	VR-2104R 92
VR-2101S 76	VR-2102S 81	VR-2103S 81	VR-2104S 81
VR-2101T 81	VR-2102T 85	VR-2103T 85	VR-2104T 85
VR-2811S 116	VR-2822S 123	VR-2833S 123	VR-2844S 123
VR-2811T 121	VR-2822T 130	VR-2833T 130	VR-2844T 130

50 Hz

IR-2101HL $87	IR-2102HL $ 96	IR-2103HL $ 96	IR-2104HL $ 96
IR-2101KL 95	IR-2102KL 100	IR-2103KL 100	IR-2104KL 100
IR-2101PL 87	IR-2102PL 96	IR-2103PL 96	IR-2104PL 96
IR-2101RL 95	IR-2102RL 100	IR-2103RL 100	IR-2104RL 100
IR-2101SL 82	IR-2102SL 87	IR-2103SL 87	IR-2104SL 87
IR-2101TL 87	IR-2102TL 96	IR-2103TL 96	IR-2104TL 96
VR-2101HL $87	VR-2102HL $ 96	VR-2103HL $ 96	VR-2104HL $ 96
VR-2101KL 96	VR-2102KL 100	VR-2103KL 100	VR-2104KL 100
VR-2101PL 87	VR-2102PL 96	VR-2103PL 96	VR-2104PL 96
VR-2101RL 96	VR-2102RL 100	VR-2103RL 100	VR-2104RL 100
VR-2101SL 83	VR-2102SL 87	VR-2103SL 87	VR-2104SL 87
VR-2101TL 87	VR-2102TL 96	VR-2103TL 96	VR-2104TL 96

400 Hz

IR-2101HQ $102	IR-2102HQ $106	IR-2103HQ $106	IR-2104HQ $106
IR-2101KQ 106	IR-2102KQ 110	IR-2103KQ 110	IR-2104KQ 110
IR-2101PQ 102	IR-2102PQ 106	IR-2103PQ 106	IR-2104PQ 106
IR-2101RQ 106	IR-2102RQ 110	IR-2103RQ 110	IR-2104RQ 110
IR-2101SQ 98	IR-2102SQ 102	IR-2103SQ 102	IR-2104SQ 102
IR-2101TQ 102	IR-2102TQ 106	IR-2103TQ 106	IR-2104TQ 106
VR-2101HQ $102	VR-2102HQ $106	VR-2103HQ $106	VR-2104HQ $106
VR-2101KQ 106	VR-2102KQ 110	VR-2103KQ 110	VR-2104KQ 110
VR-2101PQ 102	VR-2102PQ 106	VR-2103PQ 106	VR-2104PQ 106
VR-2101RQ 106	VR-2102RQ 110	VR-2103RQ 110	VR-2104RQ 110
VR-2101SQ 98	VR-2102SQ 102	VR-2103SQ 102	VR-2104SQ 102
VR-2101TQ 102	VR-2102TQ 106	VR-2103TQ 106	VR-2104TQ 106

Prices are per unit in quantities 1-9 (except as noted otherwise) fob Orlando, FL, not including applicable taxes. Terms are net 30 days.
All prices are subject to change without notice.
Consult factory for quantity discounts.

Subsidiary,
Magnetics & Electronics, Inc.

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

Majestic Industries Inc.
Teterboro, N J

HALL GENERATOR PRICE LIST

Hall Generators — Bulk Material (Quantity 1-9)

BH-200 Hall-Pak	$ 55.25
BH-201 Hall-Pak	301.25
BH-202 Hall-Pak	110.25
BH-203 Hall-Pak	59.00
BH-204 Hall-Pak	150.25
BH-205 Hall-Pak	149.00
BH-206 Hall-Pak	29.50
BH-207 Hall-Pak	187.50
BH-208 Hall-Pak	417.00
BH-209 Hall-Pak	417.00
BH-700 Hall-Pak	18.00
BH-701 Hall-Pak	149.00
BH-702 Hall-Pak	59.00
BH-703 Hall-Pak	732.00
BH-704 Hall-Pak	150.25
BH-705 Hall-Pak	60.00
BH-706 Hall-Pak	430.50
BH-850 Hall-Pak	68.50
BH-700K Hall-Pak Kit	36.00

Hall Generators — Thin Film (Quantity 1-9)

FH-301 Hall-Pak	$ 16.50
FH-302 Hall-Pak	16.50
FH-300K Hall-Pak Kit	34.00

Hall Generators — High Performance (Quantity 1-9)

BHT-900 Hall-Pak, High Field Transverse, uncalibrated	$164.00
BHA-900 Hall-Pak, High Field Axial, uncalibrated	164.00
BHT-910 Hall-Pak, High Linearity Transverse	273.00
BHA-910 Hall-Pak, High Linearity Axial	273.00
BHT-921 Hall-Pak, High Field/Cryogenic Transverse, uncalibrated	210.00
BHA-921 Hall-Pak, High Field/Cryogenic Axial, uncalibrated	257.50

TERMS: f.o.b. Orlando, FL; Net 30 Days. Prices do not include taxes and are subject to change without notice.

Write for quantity prices.

FW
Subsidiary.
Magnetics & Electronics, Inc.

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

GENERAL PURPOSE HALL GENERATORS

BH-200 SERIES

- **HIGH RELIABILITY**
- **MANY GENERAL PURPOSE CONFIGURATIONS**
- **SMALL SIZE**

GENERAL DESCRIPTION

The BH-200 series of Hall effect magnetic field sensors consists of ten models designed to meet the requirements of most magnetic field measurement applications. The sensors are small, solid state devices. They produce a voltage which is proportional to the product of the control current and the magnetic field component normal to the Hall active area. Each unit has four electrical connections. Two carry the control current (I_c) and the other two supply the Hall voltage.

The BH-200 models are built in various configurations to measure axial, transverse, and tangential magnetic field components. The sensitivities range from 6 to 60 mV/kG and the input/output levels are on the order of several ohms. Detailed specifications are included in the chart on the following page.

APPLICATIONS

Current sensors

Proximity sensors

Rotary speed sensors

Watt measurement

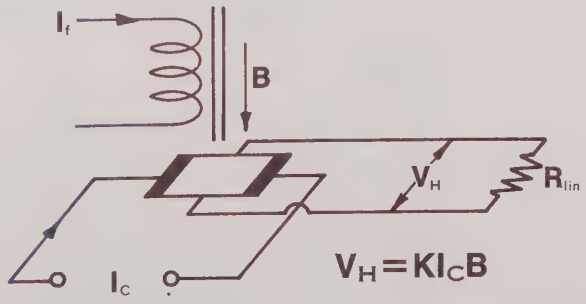
Multipliers

Permanent magnet measurements

Air gap measurements

Magnetic circuit design

Flux leakage measurements



This schematic representation illustrates both the measuring and multiplying capabilities of a Hall generator. By holding I_C constant, V_H becomes a direct function of B, the magnetic flux density. If both I_C and B are variable, V_H is proportional to the product of the two functions. Holding B and I_C constant, V_H becomes a function of the angle between B and the plane of the Hall-generator active area.

The devices listed on the following pages are standard and available from stock.

Special units are available to fit your application.

NOVEMBER 1978 REVISED LITHO IN U.S.A. NUMBER 69900

	BH-200	BH-201	BH-202	BH-203	BH-204
Rated control current, I_{cn}	150mA	100mA	100mA	100mA	100mA
Maximum continuous control current, I_{cmos} (in 25°C static air)	250mA	150mA	150mA	250mA	150mA
Open circuit magnetic sensitivity, γ_B (at rated I_{cn}, B = 1.0 kG)	15mV/kG ±25%	12mV/kG ±25%	10mV/kG ±25%	10mV/kG ±25%	11mV/kG ±25%
Misalignment voltage, V_M (B = O, I_c = 100 mA)	100μV max	250μV max	100μV max	100μV max	200μV max
Inductive null constant, A (see note)	.003 cm²*	.01 cm²*	.002 cm²*	.003 cm²*	.002 cm²*
Hall output load resistance, R_{lin} (for optimum linearity 0 to 10 kG)	5Ω*	7Ω*	5Ω*	5Ω*	7Ω*
Linearity error with R_{lin} termination (0 to 10 kG)	1% max	1.5% max	1% max	1% max	1.5% max
Open circuit sensitivity constant; K_{HOC} (B = 10 kG)	0.10V/A·kG ±25%	0.12V/A·kG ±25%	0.10V/A·kG ±25%	0.10V/A·kG ±25%	0.11V/A·kG ±25%
Sensitivity constant K_{lin} (with R_{lin} termination)	.75K_{HOC}*	.75K_{HOC}*	.65K_{HOC}*	.75K_{HOC}*	.65K_{HOC}*
Input resistance, R_{in} (including leads)	2.0Ω*	2.3Ω*	2.6Ω*	1.9Ω*	2.7Ω*
Output resistance, R_{out} (including leads)	1.7Ω*	1.8Ω*	1.8Ω*	1.3Ω*	1.9Ω*
Mean temperature coefficient of V_{HOC}** (−40°C to +100°C)	−0.08%/°C*	−0.08%/°C*	−0.08%/°C*	−0.08%/°C*	−0.08%/°C*
Mean temperature coefficient of resistance (−40°C to +100°C)	0.15%/°C*	0.15%/°C*	0.15%/°C*	0.15%/°C*	0.15%/°C*
Reversibility error of V_{HOC} (0 to 10 kG)	1% max	3% max	1% max	1% max	1% max
Resistive null voltage drift vs. temperature (I_c = 100 mA)	1μV/°C max	—	1μV/°C max	1μV/°C max	1μV/°C max
Storage temperature range	−40°C to +105°C	0.0 to +50°C	−40°C to +105°C	−40°C to +105°C	−40°C to +105°C
Operating temperature range (at rated I_c)	−40°C to +100°C	0.0 to +50°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C

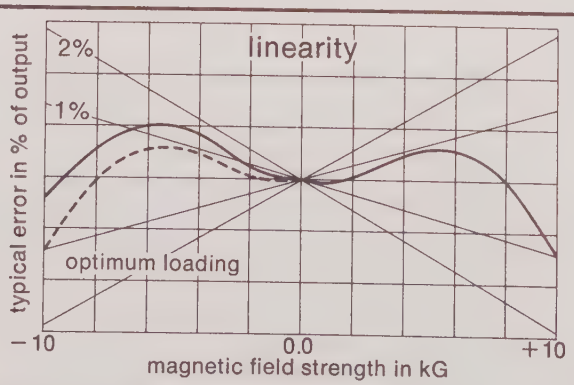
*Approximate **Constant I_c **NOTE:** In a time varying field the voltage induced into the Hall output leads, V_{ind}, is proportional to the effect

LEADS

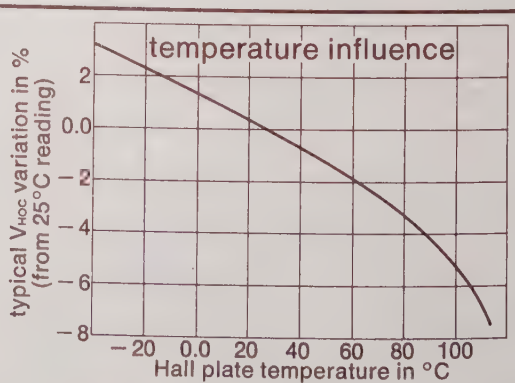
Material: AWG34 or AWG36 copper with heavy polyurethane insulation

Color code: Control Current (I_c): AWG34-r
AWG36-r

Specifications subject to change without notice.



NOTE: The dotted line is a mirror image of the curve in the right hand plane and illustrates the reversibility error.



NOTE: For an unmounted Hall device supported by its leads, typical Hall plate temperature rise is 20°C for nominal control current.

CIFICATIONS

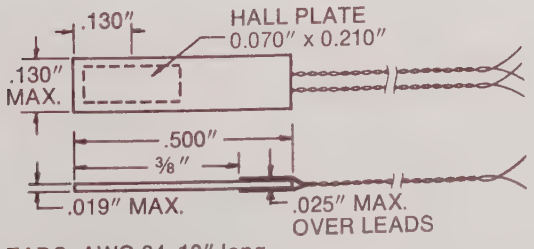
	BH-205	BH-206	BH-207	BH-208	BH-209	
	125mA	200mA	150mA	100mA	75mA	Rated control current, I_{cn}
	200mA	250mA	250mA	150mA	150mA	Maximum continuous control current, I_{cmos} (in 25°C static air)
	12.5mV/kG ±25%	55mV/kG ±25%	16mV/kG ±25%	10mV/kG ±25%	6.75mV/kG ±25%	Open circuit magnetic sensitivity, γ_S (at rated I_{cn}, B = 1.0 kG)
	100μV max	500μV max	200μV max	250μV max	100μV max	Misalignment voltage, V_M (B = O, I_c = 100 mA)
	.002 cm²*	.006 cm²*	.002 cm²*	.02 cm²*	.003 cm²	Inductive null constant, A (see note)
	6Ω*	—	7Ω*	5Ω*	100Ω max	Hall output load resistance, R_{lin} (for optimum linearity 0 to 10 kG)
	1% max	—	1.5% max	1.5% max	1.5% max	Linearity error with R_{lin} termination (0 to 10 kG)
	0.10V/A•kG ±25%	0.30V/A•kG ±25%	0.11V/A•kG ±25%	0.10V/A•kG ±25%	0.10V/A•kG ±25%	Open circuit sensitivity constant; K_{HOC} (B = 10 kG)
	.75K_{HOC}*	—	.75K_{HOC}*	.75K_{HOC}*	.8K_{HOC}*	Sensitivity constant K_{lin} (with R_{lin} termination)
	2.1Ω*	5.Ω*	2Ω*	3.0Ω*	2.5Ω*	Input resistance, R_{in} (including leads)
	2.0Ω*	3.5Ω*	1.5Ω*	3.0Ω*	2.0Ω*	Output resistance, R_{out} (including leads)
	−0.08%/°C*	−0.2%/°C*	−0.08%/°C*	−0.08%/°C*	−0.05%/°C*	Mean temperature coefficient of V_{HOC}** (−40°C to +100°C)
	0.15%/°C*	0.2%/°C*	0.15%/°C*	0.15%/°C*	0.15%/°C*	Mean temperature coefficient of resistance (−40°C to +100°C)
	1% max	1.5% max	1% max	1.5% max	1% max	Reversibility error of V_{HOC} (0 to 10 kG)
	1μV/°C max	6μV/°C max	1μV/°C max	1μV/°C max	0.5μV/°C max	Resistive null voltage drift vs. temperature (I_c = 100 mA)
	−40°C to +105°C	−40°C to +105°C	−40°C to +105°C	−40°C to +105°C	−40°C to +105°C	Storage temperature range
	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	−40°C to +100°C	Operating temperature range (at rated I_c)

A, of the Hall output loop and the amplitude and rate of change of the field. V_{ind} (measured with $I_c = 0$) = $A \frac{dB}{dt} \times 10^{-8}$ V_{ind} = volts, A = cm², B = gauss, t = sec.

), black ($-I_c$)
$+I_c$), green ($-I_c$)

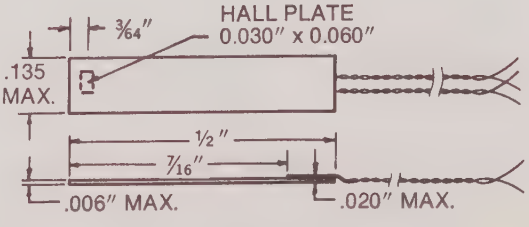
Hall voltage (V_H): AWG34-blue ($+V_H$), yellow ($-V_H$)
AWG36-red ($+V_H$), neutral ($-V_H$)

MODEL BH200: GENERAL-PURPOSE TRANSVERSE



LEADS: AWG 34, 10″ long

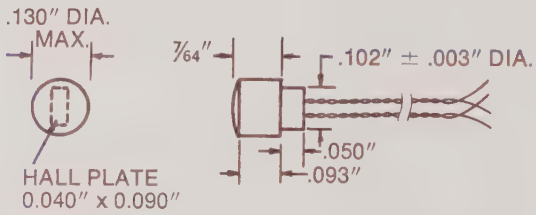
MODEL BH201: ULTRA-THIN TRANSVERSE



LEADS: AWG 36, 10″ long

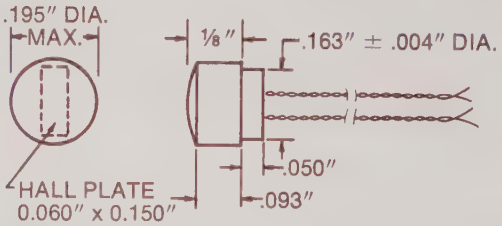
BH-200 SERIES GENERAL PURPOSE HALL GENERATORS

MODEL BH202: SMALL AXIAL



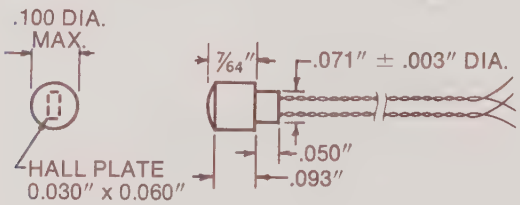
LEADS: AWG 36, 10″ long

MODEL BH203: GENERAL-PURPOSE AXIAL



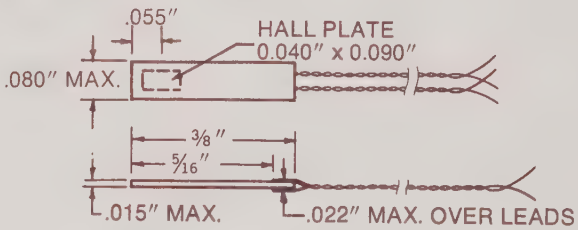
LEADS: AWG 34, 10″ long

MODEL BH204: MIDGET AXIAL



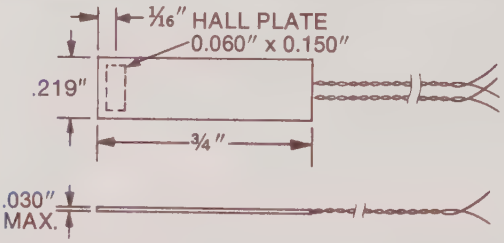
LEADS: AWG 36, 10″ long

MODEL BH205: MIDGET TRANSVERSE



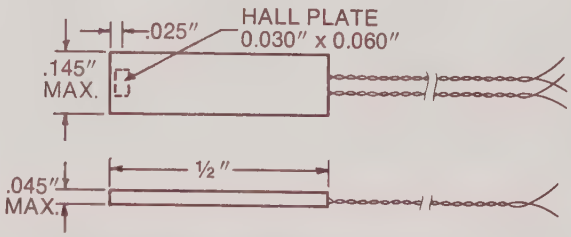
LEADS: AWG 36, 10″ long

MODEL BH206: HIGH SENSITIVITY, LOW-COST TRANSVERSE



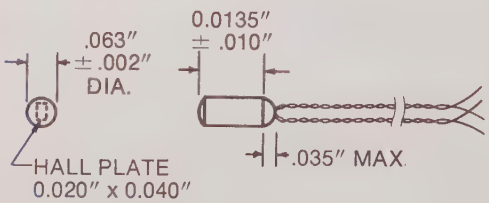
LEADS: AWG 34, 10″ long

MODEL BH207: HIGH RESOLUTION TANGENTIAL



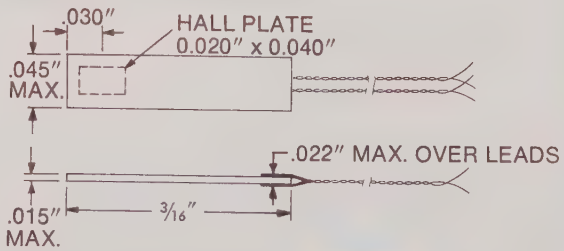
LEADS: AWG 36, 10″ long

MODEL BH208: ULTRA-MIDGET AXIAL



LEADS: AWG 36, 10″ long

MODEL BH209: ULTRA-MIDGET TRANSVERSE

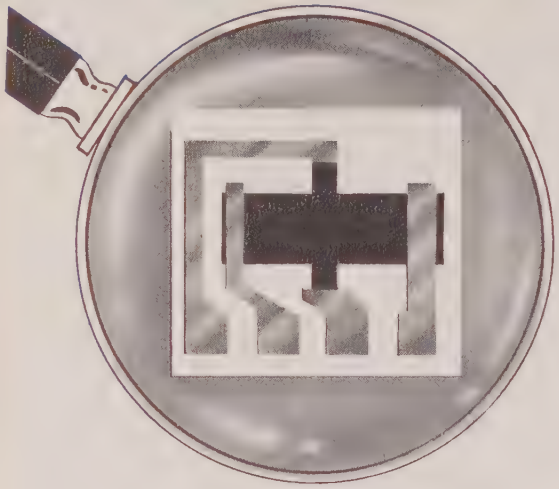


LEADS: AWG 36, 10″ long

FW BELL INC.
A Subsidiary of
The Arnold Engineering Company
4949 Freeway Drive East
Columbus, Ohio 43229
Phone: (614) 888-7501
TWX: 810-337-2851

LOW COST HALL GENERATORS

FH-300 SERIES



- **HIGH SENSITIVITY**
- **HIGH INPUT IMPEDANCE**
- **GOOD TEMPERATURE CHARACTERISTICS**
- **LONG TERM RELIABILITY**
- **LOW CURRENT REQUIREMENT**

Model FH-301

Model FH-302

SHOWN ACTUAL SIZE

GENERAL DESCRIPTION

FH-300 series Hall generators are miniature solid state Hall effect magnetic field sensing devices. There are four electrical connections to each Hall generator. Two carry the control current (I_c) and two supply the Hall output voltage. The Hall output voltage is directly proportional to the product of the control current and the magnetic field component normal to the Hall active area.

The model FH-301 has conventional wire leads. The model FH-302 has a flexible printed circuit lead strip with contacts located on 0.1″ centers. Special printed circuit conductor patterns are available for special applications. Both the FH-301 and FH-302 are available in two different resistance ranges: 20 to 40 ohms and 40 to 80 ohms.

More detailed specifications are listed on the reverse of this sheet.

Opens new areas of application for HALL-PAK Generators

- Proximity Switches
- Linear/Angular Transducers
- Brushless dc Motors
- Ignition Systems
- Magnetic Card Reader
- Current Probes
- Magnetic Tape Heads
- Nondestructive Memory Readout
- Clamp-on Ammeters
- Gaussmeters
- Power Transducers
- Guidance Systems
- Electronic Compass

JUNE 1972 REPLACEMENT Printed in U.S.A. NUMBER 70050

FH-300 SERIES — LOW COST HALL GENERATORS

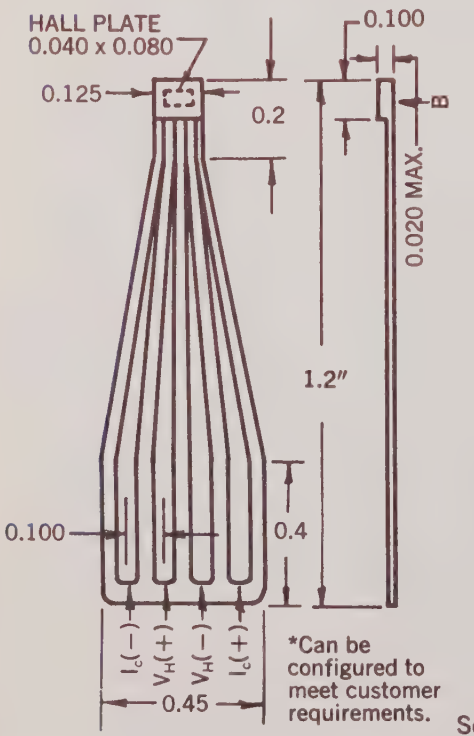
Electrical Specifications (Typical For All Models)

POLARITY: With field direction as shown and I_c entering the red lead, or I_c (+) terminal, the positive Hall voltage will appear at the blue lead, or V_H(+) terminal.

NOTE: Unless otherwise specified all specifications apply at nominal control current with T = 25°C. Heat sinking can enhance performance in several respects. For information concerning operating on a heat sink, such as the pole face of a magnet, contact F. W. Bell, Inc., Semiconductor Division.

Dash Number	–020	–040
Input Resistance, R_{in}	20-40 Ω	40-80 Ω
Output Resistance, R_{out}	2.2 R_{in} approx.	2.2 R_{in} approx.
Magnetic Sensitivity γ_B, min. @ I_{cn}	10.0 mV/kG	12.0 mV/kG
Product Sensitivity, γ_{IB}, min.	0.4 V/A•kG	0.8 V/A•kG
Resistive Residual Voltage, V_M @ I_{cn}, B=0	5 mV max.	6 mV max.
Nominal Control Current, I_{cn}	25 mA	15 mA
Maximum Continuous Control Current, I_{cmos}	50 mA	30 mA
Mean Temperature Coefficient of V_H (−20°C to +80°C), β_T	−0.1%/°C max.	−0.1%/°C max.
Mean Temperature Coefficient of Resistance, α_T (−20°C to +80°C)	0.1%/°C max.	0.1%/°C max.
Temperature Dependence of Resistive Residual Voltage, D_T @ I_{cn} (−20°C to +80°C)	10 μV/°C max.	10 μV/°C max.
Thermal Resistance, Hall Plate to Ambient, $R\theta_{P\text{-}A}$	0.8°C/mW	0.8°C/mW
Thermal Resistance, Hall Plate to Encapsulation, $R\theta_{P\text{-}E}$	0.04°C/mW	0.04°C/mW
Operating Temperature Range	−55°C to +100°C	−55°C to +100°C
Storage Temperature Range	−55°C to +120°C	−55°C to +120°C

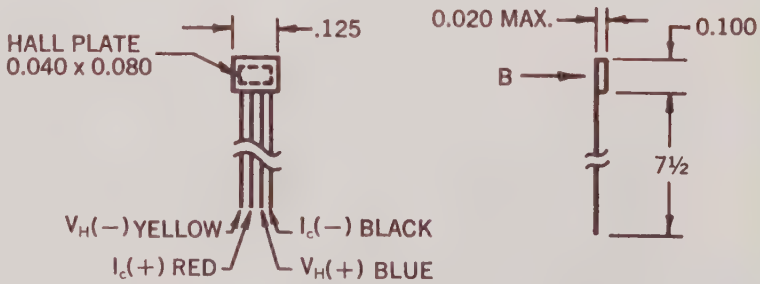
MODEL FH-302
With Printed Circuit Lead Strip*



*Can be configured to meet customer requirements.

Scale: 2X

MODEL FH-301
With Wire Leads



Scale: 2X

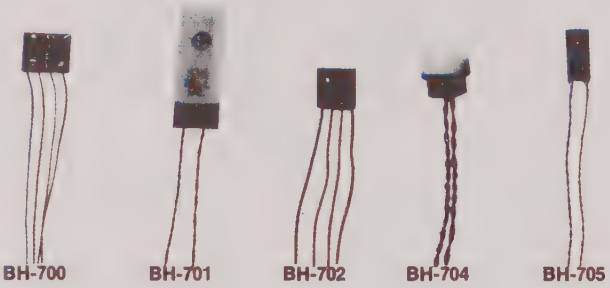
Specifications subject to change without notice.

Subsidiary, Magnetics & Electronics, Inc.

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

GENERAL PURPOSE HALL GENERATORS

BH-700 SERIES single-axis



APPLICATIONS

magnetic field measurements

electrical power measurements

current sensors

brushless dc motors

compass

proximity sensors

watt-hour meters

FEATURES

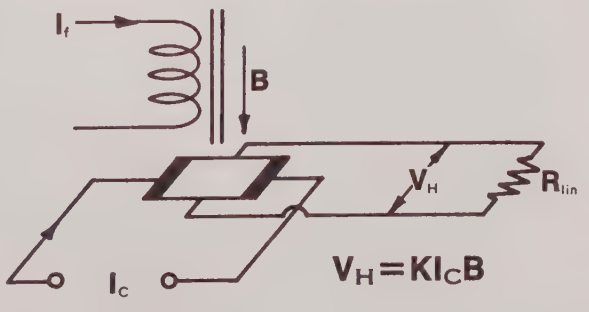
- **Solid-State Reliability**
- **Broad Frequency Response**
- **BH-700: Low Cost**
- **BH-701**
  BH-704: Rugged
  High-Linearity
  High-Stability
  Low Temperature Coefficient
- **BH-702: Ferrite-embedded**
  (for gap applications)
- **BH-705: High-Stability**
  (ideal for general field measurements)

GENERAL DESCRIPTION

The BH-700 Series Hall generators have been designed to meet the requirements of a wide range of magnetic field measurement applications. These Hall generators are small, solid-state devices. They provide an output voltage proportional to the product of control current and ambient flux density. (see illustration below)

Five BH-700 series single-axis models are available to measure axial and transverse magnetic field components. The sensitivities range from 7.5 to 50 mV/KG, and the input/output impedance levels are on the order of 2 to 6 ohms.

The five available models vary from the low cost, moderate accuracy BH-700 to the rugged, high-linearity, high-stability BH-701 and BH-704. The BH-702 is a ferrite-embedded device designed for gap applications, and the high-stability BH-705 is ideal for general field measurements. Detailed specifications are included in the chart on the following page.



This schematic representation illustrates both the measuring and multiplying capabilities of a Hall generator. By holding I_c constant, V_H becomes a direct function of B, the magnetic flux density. If both I_c and B are variable, V_H is proportional to the product of the two functions. Holding B and I_c constant, V_H becomes a function of the angle between B and the plane of the Hall-generator active area.

The devices listed on the following pages are standard and available from stock.

Special units are available to fit your application.

ELECTRICAL SPECIFICATIONS

Unless otherwise noted: B=1 kG, $I_c=I_{cn}$, T=25°C, Static air.

	BH-700	BH-701	BH-702	BH-704	BH-705
Rated control Current, I_{cn}	200 mA	100 mA	200 mA	100 mA	100 mA
Maximum continuous control current I_{cmos} (B≤3 kG)	250 mA	300 mA	300 mA	300 mA	250 mA
Product sensitivity	0.25 V/A·kG min	0.075 V/A·kG ±20%	**	0.075 V/A·kG ±20%	0.1 V/A·kG ±25%
Open circuit magnetic sensitivity, γ_B	50 mV/kG min	7.5 mV/kG±20% $I_c=I_{cn}$ 22 mV/kG±20% $I_c=I_{cmos}$	**	7.5 mV/kG±20% $I_c=I_{cn}$ 22 mV/kG±20% $I_c=I_{cmos}$	10 mV/kG ±25%
Misalignment voltage, V_M (B=O)	1.5 mV max	75 μV max	250 μV max	75 μV max	300 μV max
Linearity error with R_{lin} termination	1.5% of reading 0 to 10 kG	**	—	**	1% of reading 0 to 10 kG
Input resistance, R_{in}	5.5 Ω max	2 Ω max	3.5 Ω max	2.5 Ω max	2.2 Ω max
Output resistance, R_{out}	5.5 Ω max	2 Ω max	3.5 Ω max	2.5 Ω max	2 Ω max
Mean temperature coefficient of V_{HOC}, β_T	−0.2%/°C* −40 to +80°C	−0.04%/°C* −40 to +80°C	−0.07%/°C* −40 to +60°C	−0.04%/°C* −40 to +80°C	−0.08%/°C max −40 to +100°C
Mean temperature coefficient of resistance	+0.20%/°C* −40 to +80°C	+0.18%/°C* −40 to +80°C	+0.18%/°C* −40 to +60°C	+0.18%/°C* −40 to +80°C	+0.2%/°C* −40 to +100°C
Mean temperature coefficient of misalignment voltage	6 μV/°C typ	0.3 μV/°C typ	2.5 μV/°C typ	0.5 μV/°C max	1 μV/°C max
Storage temperature range	−40°C to +105°C	−40°C to +105°C	−40°C to +105°C	−40°C to +105°C	−65°C to +105°C
Operating temperature range	−40°C to +100°C	−40°C to +100°C	−40°C to +75°C	−40°C to +100°C	−65°C to +100°C
Zero field thermal voltage	—	5 μV max	—	5 μV max	5 μV max
Thermal resistance, plate to ambient	—	0.1°C/mW*	—	—	0.5 C/mW*
Thermal resistance, plate to substrate	—	0.01°C/mW*	—	—	0.025°C/mW*

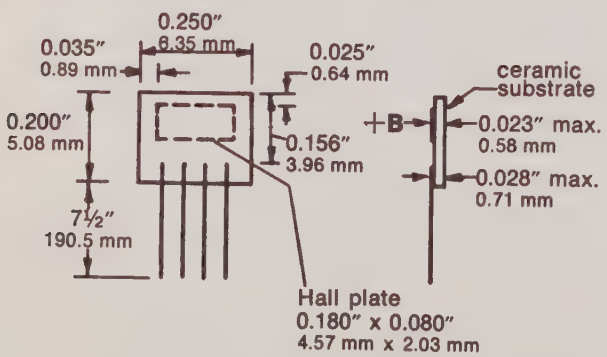
*Approximate **See individual Hall generator specifications on the following pages

COLOR CODE

Control Current (I_c): red ($+I_c$), black ($-I_c$)
Hall voltage (V_H): blue ($+V_H$), yellow ($-V_H$)

model BH-700

low cost transverse



Applications: control and moderately accurate magnetic field measurements.

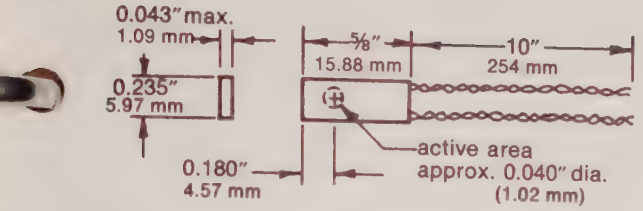
Leads: 34 AWG copper wire with polyurethane insulation

Encapsulation: red epoxy, Hall plate side only

Polarity: With the magnetic field vector as shown and I_c entering the red lead, the positive Hall voltage will appear at the blue lead.

Typical optimum output loading: 500 Ω and greater.

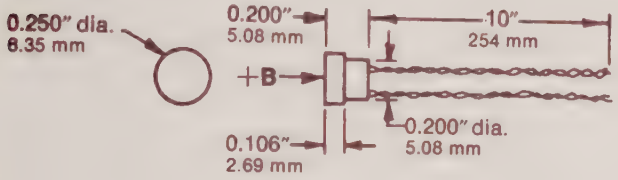
model BH-701
high-linearity transverse



Leads: #34 AWG copper with polyurethane insulation

Polarity: With the red cross facing the north pole of a magnet and I_c entering the red lead, the positive Hall voltage will appear at the blue lead.

model BH-704
high-linearity axial



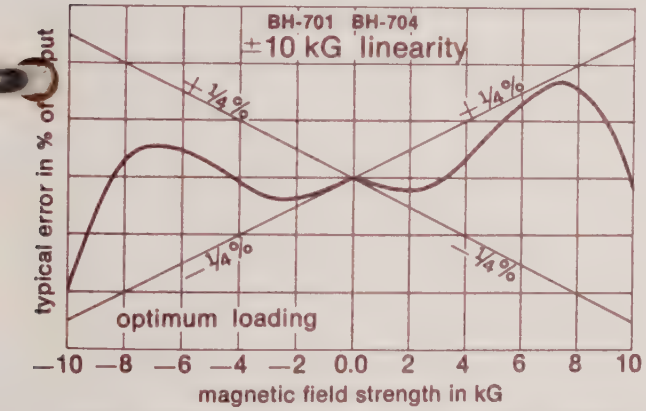
Leads: #34 AWG copper with polyurethane insulation

Polarity: With the magnetic field vector as shown and I_c entering the red lead, the positive Hall voltage will appear at the blue lead.

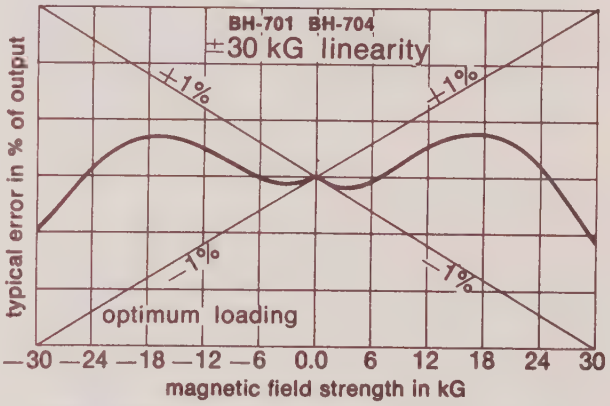
Linearity: (See below)

V_H vs. B, −10 to +10 kG: ±0.25 % of reading, max.
V_H vs. B, −30 to +30 kG: ±1.0 % of reading, max.
V_H vs. I_c, 0 to 100 mA: ±0.1 % of reading, max.
V_H vs. I_c, 0 to 300 mA: ±1.0 % of reading, max.

Encapsulation: The BH-701 and the BH-704 are encapsulated in a rugged aluminum oxide ceramic and epoxy case for excellent heat transfer and strength.



Note: Optimum loading range for ±10 kG operation is 20-50 Ω.



Note: Optimum loading range for ±30 kG operation is 90-200 Ω.

LINEARITY DEVIATION CURVES

In order to give you the means to correct for linearity error, linearity deviation curves for −10 kG to +10 kG and −30 kG to +30 kG are furnished with each BH-701 and BH-704. These curves are plotted individually for each device using a test stand developed by F. W. Bell, Inc.

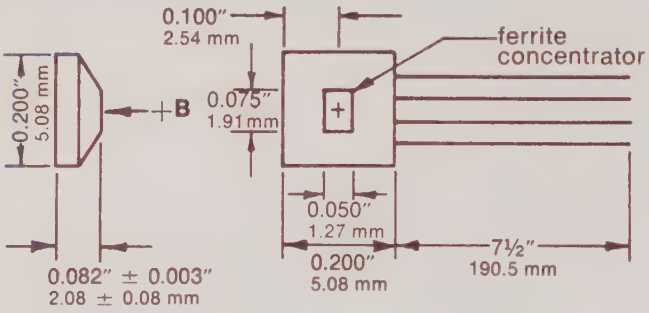
The field is swept through the indicated range, and the output of the Hall device is balanced against the output of a rotating coil (which is inherently linear). The difference is the linearity deviation of the Hall device. This is amplified as required and plotted on a standard form using an X-Y recorder. To take advantage of the wide dynamic range of the device, the deviation is plotted as a percent of reading instead of percent of full scale; hence, the "bow-tie" error limit lines on the form.

The control current is supplied from a constant current source at the indicated value. The linearity error is minimized for the given flux density range by adjusting the value of the Hall output terminating resistor. The slope of the linear reference device is adjusted so that the positive and negative errors are equally distributed. This slope is accurately determined and is indicated on the curve. By making the plot for both field directions, the reversibility error is automatically included. The zero field residual voltage is compensated with a bucking voltage.

BH-700 SERIES
single-axis

GENERAL PURPOSE HALL GENERATORS

model BH-702
ferrite-embedded transverse



Applications: current sensor
compass

Leads: #34 AWG stranded (7 x 42) silver plated copper, thin wall teflon insulation.

Air gap: between concentrator and substrate, 0.0025″ nominal and 0.003″ maximum.

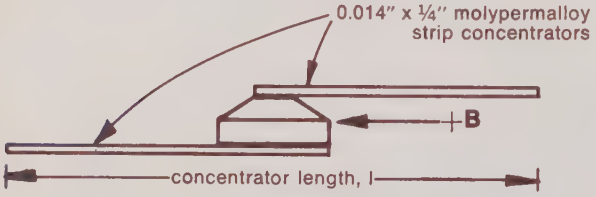
Sensitivity: With the unit suspended in a free field of 100 oersteds and 200 mA control current, the open circuit Hall voltage is 9.0 mV minimum. In a closed magnetic circuit driven with 2.5 ampere-turns, V_H is at least 8 mV with 200 mA control current.

Polarity: With the magnetic field vector as shown and I_c entering the red lead, the positive Hall voltage will appear at the blue lead.

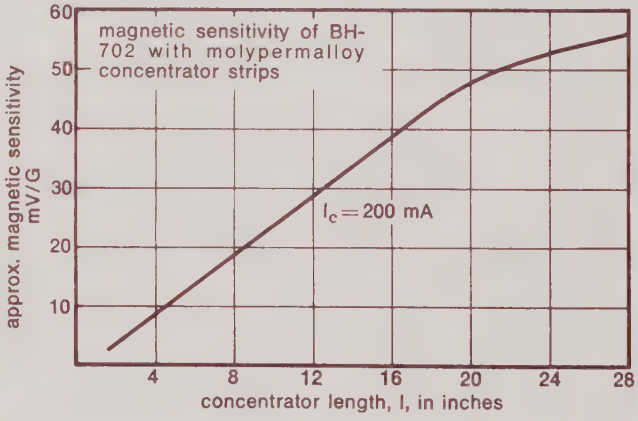
Optimum Loading: approx. 10Ω

Using flux concentrators to increase sensitivity:

Flux concentrators can be used to increase Hall generator sensitivity. The ferrite-embedded BH-702 is particularly well-suited for concentrator modifications, because of the small gap possible. The sensitivity curve on the right illustrates how BH-702 magnetic sensitivity varies with concentrator length.



BH-702 with concentrator strips

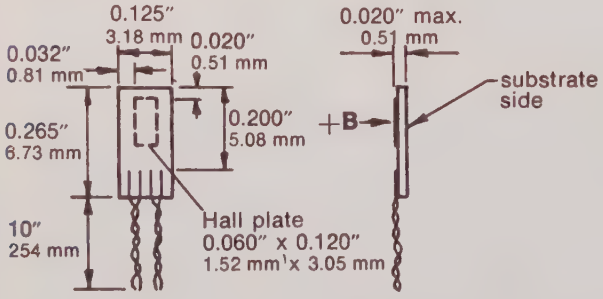


The linear portion of this sensitivity curve can be approximated by the following equation: $\gamma_B \cong (2.5 \times l) - 1$

Where:

γ_B = magnetic sensitivity in mV/G
l = total concentrator length
(not exceeding 18″)

model BH-705
general-purpose transverse



Applications: gaussmeter sensor
gyro sensor
control systems*
flux null measurement*

Leads: #34 AWG copper with polyurethane insulation.

Polarity: With the magnetic field vector as shown and I_c entering the red lead, the positive Hall voltage will appear at the blue lead.

Optimum Loading: approx. 10Ω

*BH-705's excellent offset voltage stability makes it ideal for control system or flux nulling applications. Offset voltage drift is less than 10 μV/year.

Specifications subject to change without notice.

Printed in U.S.A.

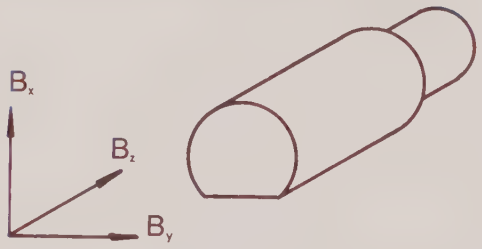
Subsidiary,
Magnetics & Electronics, Inc

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

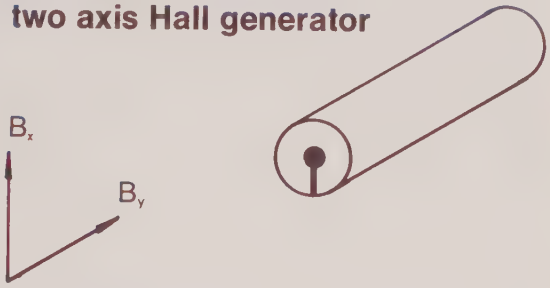
MULTI-AXIS HALL GENERATORS

BH-700 SERIES multi-axis

BH-703
three axis Hall generator



BH-706
two axis Hall generator



three axis

The BH-703 multi-axis Hall generator consists of three individual Hall elements oriented in mutually perpendicular planes and encapsulated in a small epoxy package. This enables the BH-703 to produce voltages proportional to the three orthogonal components (B_x, B_y, B_z) of a magnetic flux in any direction. Thus the BH-703 may be permanently mounted or arbitrarily oriented to sense fields in any direction.

The magnitude of the flux vector, B , can be found using the following relation.

$$B = \sqrt{B_x^2 + B_y^2 + B_z^2}$$

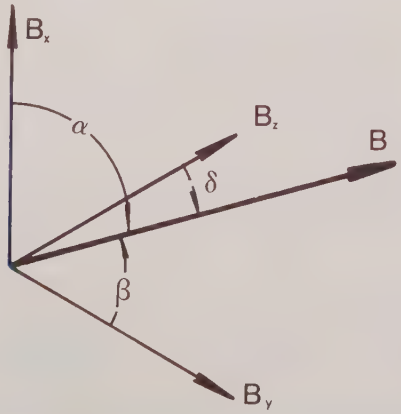
The flux direction may be found using the following relations.

$\alpha = \cos^{-1} B_x/B$

$\beta = \cos^{-1} B_y/B$

$\delta = \cos^{-1} B_z/B$

where α, β, δ are the angles between B and X,Y,Z respectively



two axis

A single Hall element produces a voltage proportional to the magnetic flux density normal to its surface. The BH-706 multi-axis Hall generator consists of two Hall elements mounted in mutually perpendicular planes and encapsulated in a small epoxy package. This enables the BH-706 to produce voltages proportional to two perpendicular components (B_x, B_y) of a magnetic field. Thus the BH-706 may be permanently mounted to sense field components in its X,Y planes.

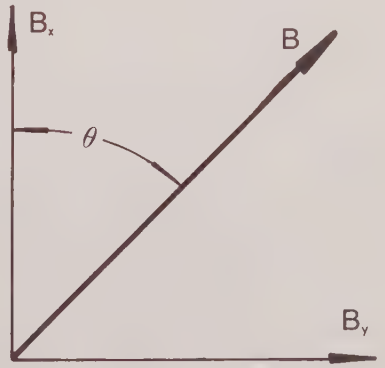
The magnitude of the flux vector, B , within the X,Y plane can be found using the following equation.

$$B = \sqrt{B_x^2 + B_y^2}$$

The direction of B can be computed using the following equation.

$\theta = \tan^{-1} B_y/B_x$

where θ is the angle between B and X.



MULTI-AXIS HALL GENERATORS

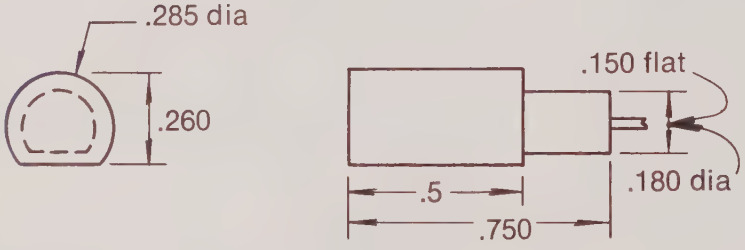
ELECTRICAL SPECIFICATIONS
FOR EACH AXIS

Unless otherwise noted: B = 1 kG, $I_c = I_{cn}$, T = 25°C, Static air.

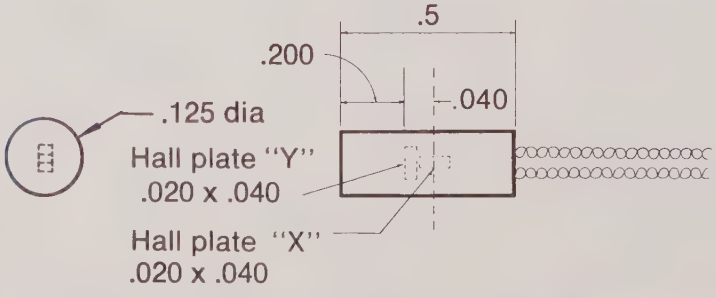
	BH-703	BH-706
Zero field residual voltage V_{MT} (B = 0, I_c = 100 mA)	100 μV maximum	200 μV maximum
Angularity	Hall plates, perpendicular within 2°	
Control current (a) nominal (b) max continuous	 100 mA 300 mA	
Input and output resistance, B = 0	3 Ω maximum	
Magnetic sensitivity, (when terminated into optimum load, R_{lin})	7.5 mV/kG ± 20%	
Sensitivity matching	within 1%	
Temperature dependence (a) of Hall voltage (b) of resistance (c) of zero field residual voltage	 −0.04% / °C max +0.15 % / °C approx 0.5μV / °C max	
Operating temperature range	−40 °C to +100 °C	

multi-axis linearity

The linearity is within ±1.0% of reading from −10 kG to + 10 kG with resistive null voltage compensated to zero and with R_{lin} termination.
NOTE: Special order units are available with ±2.0% linearity from −30 kG to +30 kG. The value of R_{lin} is specified for each element.



BH-703



BH-706

leads: #34 AWG copper with polyurethane insulation, approximately 20" long, the BH-706 has 8 leads, the BH-703 has 12 leads

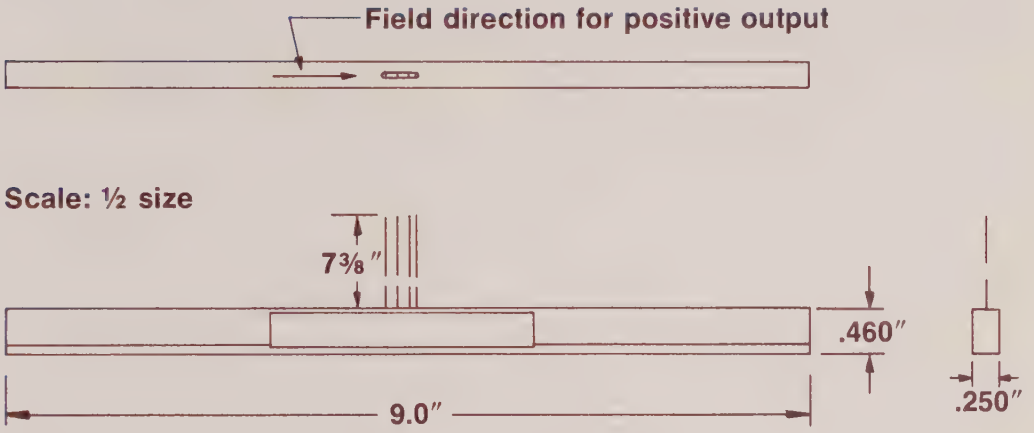
polarity: when the magnetic field vectors are oriented as shown, and I_c enters the red leads, the positive Hall voltage appears at the blue leads

A Subsidiary of
The Arnold Engineering Company

BELL INC.
4949 Freeway Drive East
Columbus, Ohio 43229
Phone: (614) 888-7501
TWX: 810-337-2851

HIGH SENSITIVITY HALL GENERATOR

MODEL BH-850



LEADS

Material: AWG 34 stranded (7 x 42) silver plated copper, thin wall teflon insulation.
Color code: Control Current (I_c) — red, black; Hall Voltage (V_H) — blue, yellow

POLARITY

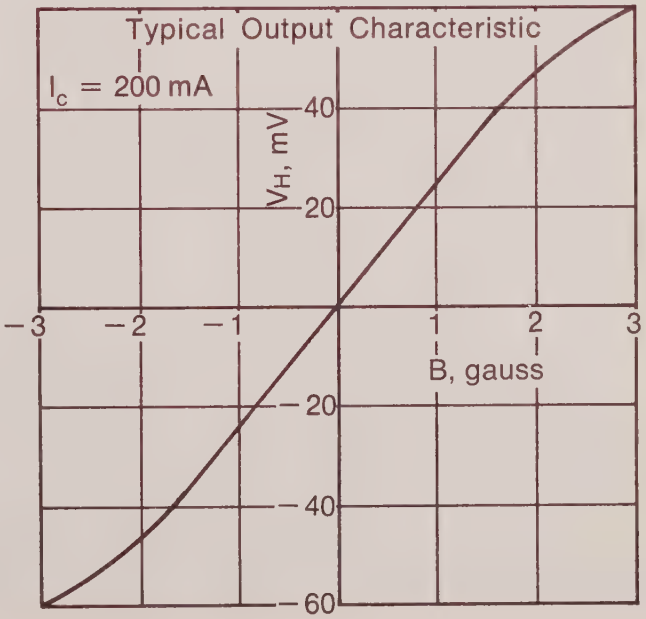
With field direction as shown and I_c entering the red lead, the positive Hall output voltage will appear at the blue lead.

WEIGHT

Twenty grams.

ELECTRICAL SPECIFICATIONS

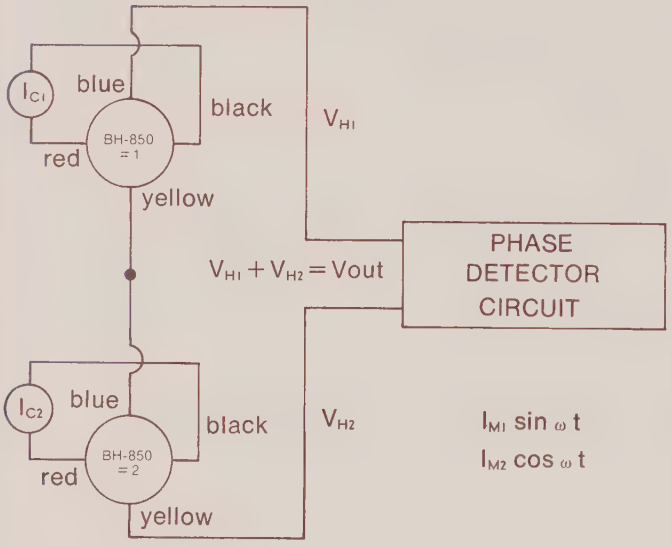
Nominal control current, I_{cn}	200 mA
Maximum continuous control current, I_{cmos} (in static air with T = 25° C)	300 mA
Input resistance, R_{in}	3.5 Ω max.
Output resistance, R_{out}	3.5 Ω max.
Sensitivity, γ_B (I_c = 200 mA, open circuit)	18 mV/g min.
Misalignment voltage, V_M (B = 0, I_c = 200 mA, T = 25° C)	± 200μV max.
Temperature dependence of misalignment voltage:	±2.5 μV/° C max.
Temperature coefficient of open circuit hall voltage, V_{HOC}, from −55° C to +85° C	−0.1% / ° C max.
Operating temperature range	−55° C to +85° C
Storage temperature range	−55° C to +85° C



MODEL BH-850

HIGH SENSITIVITY HALL GENERATOR

A common application of the BH-850 Hall generator is in a solid state compass. This compass can be constructed by positioning two BH-850's as an orthogonal pair in a horizontal plane. The block diagram below illustrates the typical circuit components for this application.



I_{C1} and I_{C2} are isolated control supplies. Their waveforms are sinosoidal and have a relative phase shift of 90°. The BH-850 Hall generator senses only that component of the Earth's magnetic field (approximately ½ gauss) which is parallel to its longitudinal axis. Therefore, if B_{HE} is the horizontal component of the Earth's magnetic field and Θ is the angle between B_{HE} and the longitudinal axis of the Hall generator, then the output voltages (V_{H1} and V_{H2}) can be expressed as

$$V_{H1} = K_1 B_{HE} \sin \Theta \sin \omega t$$
$$V_{H2} = K_2 B_{HE} \cos \Theta \cos \omega t$$

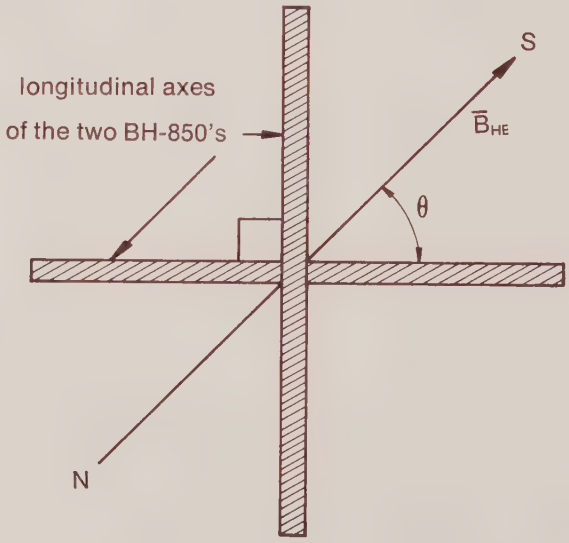
where: $K_1 = \gamma_{IB_1} I_{M_1}$

$K_2 = \gamma_{IB_2} I_{M_2}$

These can be summed to give

$$V_{H1} + V_{H2} = Vout = K_3 B \cos (\Theta - \omega t)$$

This output is a sinusoid whose phase shift is a basic direction signal. The phase is a direct indication of the physical angle between the Earth's magnetic field and a reference direction on the Hall generator compass assembly. The output signal may be fed into a phase detection circuit as illustrated in the block diagram. The accuracy and output characteristics of the detection circuitry have a direct bearing on the resolution that is obtainable with such a solid state compass. The designer should also take into account the effects of the magnetic environment around a compass using the BH-850 Hall generators. Any mass of magnetic material in the area will either distort the Earth's magnetic field or act to shield the compass from the Earth's magnetic field.



A Subsidiary of
The Arnold Engineering Company

BELL INC.
4949 Freeway Drive East
Columbus, Ohio 43229
Phone: (614) 888-7501
TWX: 810-337-2851

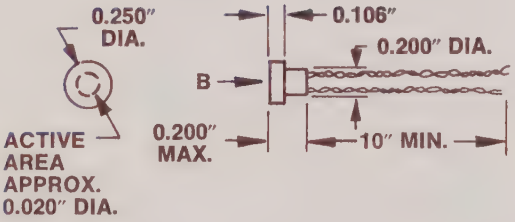
HIGH PERFORMANCE HALL GENERATORS

BH 900 SERIES
cryogenic
high linearity
high field

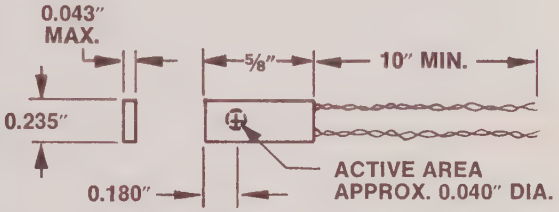
F. W. Bell, Inc. introduces the Series 900 Hall-Paks, a new line of high performance Hall generators bringing new standards of linearity, field range, and operating temperature range to the area of magnetic field measurements. This significant advancement in magnetic field sensors is the result of years of intensive development by F. W. Bell's Semiconductor Division. All units in this series are encapsulated in rugged, epoxy-sealed ceramic cases. A room temperature linearity error curve from −30 to +30 kG will be supplied indicating optimum operating conditions for each device. The models 900 and 921 are not calibrated above 30 kG.

- **HIGH LINEARITY**
  0.1% to 30 kG (model 910)
- **CRYOGENIC OPERATION**
  1.5 to 370 Kelvin (model 921)
- **WIDE DYNAMIC RANGE**
  −150 to +150 kilogauss
  (models 900 & 921)
- **50 ppm/°C TEMPERATURE STABILITY**
  (models 900 & 910)
- **SMALL SENSING AREA**
- **TRANSVERSE & AXIAL PACKAGES**

MECHANICAL SPECIFICATIONS



AXIAL HALL GENERATORS
BHA-900, 910 & 921



Note: Cross indicates tail of magnetic field vector.

TRANSVERSE HALL GENERATORS
BHT-900, 910 & 921

LEADS

Material: AWG 34 copper with teflon insulation (Model 921) or polyurethane insulation (Models 900 & 910).
Color Code: Control Current (I_c) — red, black; Hall Voltage (V_H) — blue, yellow.

POLARITY

If the control current enters the red lead (connected to the positive terminal of the current supply) and the magnetic field direction is as indicated above, a positive Hall voltage will be generated at the blue lead.

HALL PLATE LOCATION (Axial Hall Generators)

The Hall plate is symmetrical with the center line of the assembly and is located approximately 0.025″ behind the front edge of the assembly.

See other side for electrical specifications

MARCH 1974 REVISION Printed in U.S.A. NUMBER 60920

HIGH PERFORMANCE HALL GENERATORS

ELECTRICAL SPECIFICATIONS

	BHT 900	BHT 910	BHT 921	BHA 900	BHA 910	BHA 921
Nominal control current, I_{cn}	100mA	100mA	100mA	100mA	100mA	100mA
Maximum Continuous control current, I_{cmos} (in 25°C static air)	300mA	300mA	300mA	300mA	300mA	300mA
Magnetic Sensitivity, γB, $I_c = 100$ ma	0.8mV/kG ±30%	0.8mV/kG ±30%	0.8mV/kG ±30%	0.8mV/kG ±30%	0.8mV/kG ±30%	0.8mV/kG ±30%
Typical Load Required for proper linearity	500Ω	50 to 500Ω	500Ω	500Ω	50 to 500Ω	500Ω
Linearity Error ($I_c =$ 100ma) −30 to +30kG	±1.0% (max.)	±0.1% (max.)	±1.0% (max.)	±1.0% (max.)	±0.25% (max.)	±1.0% (max.)
Linearity Error ($I_c =$ 100ma) −150 to +150kG	±1.5% (max.)		±2.0% (max.)	±1.5% (max.)		±2.0% (max.)
Operating Temperature Range	−40 to +100°C	−40 to +100°C	−269 to +100°C	−40 to +100°C	−40 to +100°C	−269 to +100°C
Mean Temperature Coefficient of Hall Voltage, β_T	±50 ppm/ °C (max.)	±50 ppm/ °C (max.)	±100 ppm/ °C (max.)	±50 ppm/ °C (max.)	±50 ppm/ °C (max.)	±100 ppm/ °C (max.)
Mean Temperature Coefficient of Resistive Residual Voltage, D_T	±0.07μV/ °C (max.)	±0.07μV/ °C (max.)	±0.07μV/ °C (max.)	±0.07μV/ °C (max.)	±0.07μV/ °C (max.)	±0.07μV/ °C (max.)
Mean Temperature Coefficient of Resistance, α_T	±0.15% / °C (max.)	±0.15% / °C (max.)	±0.6% / °C (max.)	±0.15% / °C (max.)	±0.15% / °C (max.)	±0.6% / °C (max.)
Resistive Residual Voltage, Vm, ($I_c = 100$mA)	50μV (max.)	50μV (max.)	200μV (max.)	50μV (max.)	50μV (max.)	200μV (max.)
Input Resistance in Zero Field, R_{in} (including leads)	1.0Ω*	1.0Ω*	1.0Ω*	1.0Ω*	1.0Ω*	1.0Ω*
Output Resistance in Zero Field, R_{out} (including leads)	1.0Ω*	1.0Ω*	1.0Ω*	1.0Ω*	1.0Ω*	1.0Ω*

Specifications subject to change without notice.

*Approximate value.

See MIL-STD-793-1 (WP) for definitions.

Note: Unless otherwise stated, all specifications apply at nominal control current with T = 25°C.

Subsidiary.
Magnetics & Electronics, Inc
BELL INC.
6120 Hanging Moss Rd.
Orlando, FL 32807
Phone 305/678-6900
TWX: 810-853-3115

The Hall effect comes into its own.

by Frank K. Urban III and J. Gregory Frank
F. W. Bell

Liberated by recent developments in semiconductor technology, Hall effect generators now meet the challenge of a wide range of applications.

FOR NEARLY EIGHTY YEARS, the Hall effect, discovered by E. H. Hall in 1879, has remained a laboratory curiosity. The main reason Hall effect devices were impractical was that metal conductors exhibit very low levels of Hall voltage (about 10^{-6} v). However, semiconductor technology has recently developed new materials that exhibit Hall voltages three or four times greater than that of metals, and the new type of Hall devices are conquering all kinds of application areas, from the ocean depths to the orbiting satellites.

Today, Hall generators are available that range from 10 mv/kilogauss to 60 v/kilogauss in sensitivity and possess up to a 0.05% of reading linearity characteristic. Prices range from $0.90 to $600, depending on the generator type, quality, and the quantity purchased. Many new products depend on the Hall effect for their operation. Hall generators are used in the manufacture of motors, transformers, loudspeakers, razor blades, and heavy equipment tires. Hall devices are used in monitoring electric power systems, aluminum processing, copper reduction, and chlorine production. The Hall effect has truly arrived as a dependable, useful tool in today's technological society.

Current measurement is basic

Hall effect devices are widely used in current measurement. They offer both high frequency response and accurate d-c measurement. If a Hall generator is positioned near a current-carrying conductor, the Hall voltage developed is proportional to the magnitude of the field surrounding the conductor. Since the field magnitude at a particular point is proportional to the current level, the Hall voltage will also be proportional to the current level. Amplifiers may be necessary to raise this voltage to a level compatible with monitoring equipment.

The simplest current sensor configuration consists of a Hall generator mounted near a conductor (Fig. 1). This type of system is usually used only to measure relatively large currents, over 1000 ampere-turns. Two flux concentrators located perpendicular to the Hall active area, as shown in Fig. 2, raise the sensitivity of this simple system. A one-quarter inch diameter rod of ferrite or high-permeability steel makes a good concentrator. The lower measurable limit with such concentrators is about 500 ampere-turns.

A more sensitive system (Fig. 3), must be used to measure lower level currents because they may result in flux densities too low to produce usable Hall voltages. A system consisting of a core with a Hall device in a core gap can measure from zero to approximately 1000 ampere-turns. The core encloses the conductor(s) and acts as a flux concentrator, providing a suitable flux density to the Hall generator positioned in the core gap.

Other, more sophisticated systems are now in use, one of which consists of a core wound with feedback coils. The core has several gaps, with a Hall device in each gap. When placed around a current-carrying conductor, a field is generated in the core. The Hall devices sense the presence of this field and drive amplifiers which supply current to the feedback coils. The feedback current sets up a field in the core that opposes the conductor induced field. The feedback current necessary to null the induced field is proportional to the conductor current. In this system, the Hall devices are used as flux-null detectors. Neither high linearity nor fixed sensitivity are required in this application, but alignment and voltage drift with temperature and time are important.

A current sensor is designed by first determining the current level to be measured and the desired output voltage. All that remains are the theoretical calculations, construction, and design adjustments based on empirical findings in the prototype. Knowing only the current level and desired voltage, "ball-park" calculations can be performed by assuming either a core saturation level or a Hall generator sensitivity. Given a particular Hall generator or core, you can perform all the basic design calculations.

Due to fringing, gap flux density is less than the core flux density. To prevent core saturation, the gap flux density must never exceed one-half the core saturation level. This relation holds for gap lengths on the order of Hall generator thickness. Cores exhibit a hysteresis effect that shows up in the Hall voltage. Ferrite core saturation levels range from 2 kG to 4 kG, and steel core saturation levels range from 6 kG to 20 kG. Hysteresis can be minimized by increasing gap length

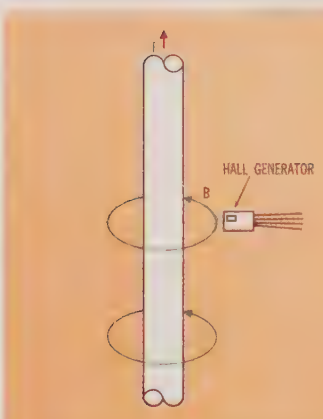


Fig. 1. A simple current sensor.

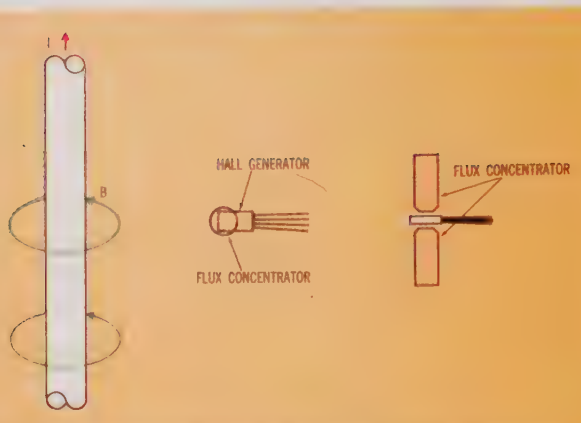


Fig. 2. Flux concentrators placed perpendicular to a Hall generator increase the sensitivity of the current sensor.

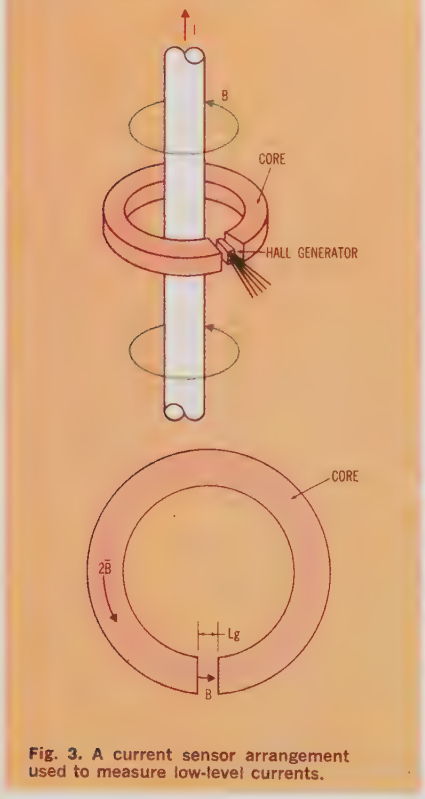


Fig. 3. A current sensor arrangement used to measure low-level currents.

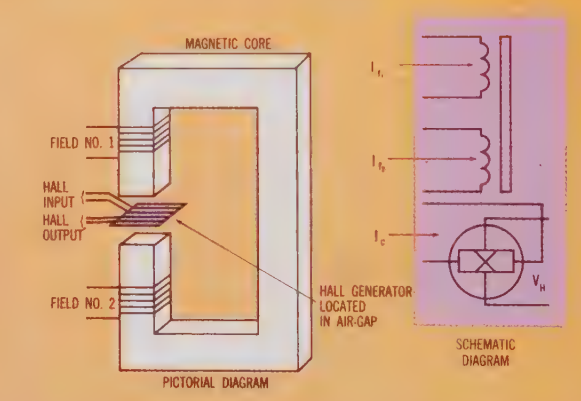


Fig. 4. Diagram of a Hall multiplier.

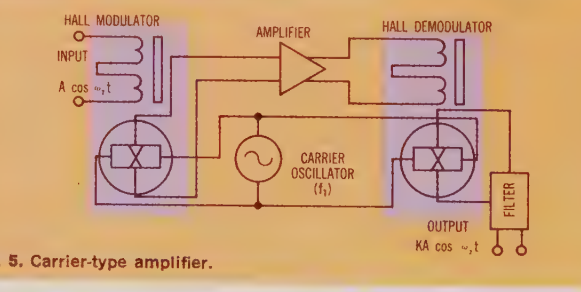


Fig. 5. Carrier-type amplifier.

and by the choice of proper material.

The following "rule-of-thumb" equations are used in Hall effect current sensor design:

$$B = NI/2l_g \quad (2)$$

$$\gamma_B = V_H/B \quad (3)$$

where B = flux density in kG
N = number of conductors
I = conductor current in amperes
l_g = gap length in mils (0.001")
See Fig. 3.
V_H = Hall voltage in mv
γ_B = magnetic sensitivity of the Hall deices in mv/kG.

Combining equations 2 and 3,

$$V_H/\gamma_B = NI/2l_g \quad (4)$$

The following is an example illustrating the use of these equations in current sensor design.

Assume that a Hall generator having a 60 mv output measuring a current of 150 ampere-turns, is needed. A suggested core would be an Arnold

continued

WHAT IS THE HALL EFFECT?

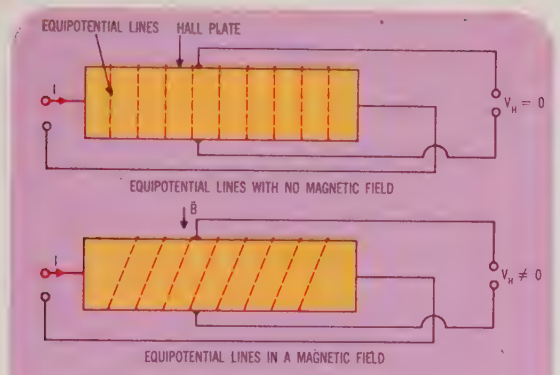


Fig. 1. Hall effect observed as a voltage, V_H, on a current-carrying conductor in a magnetic field.

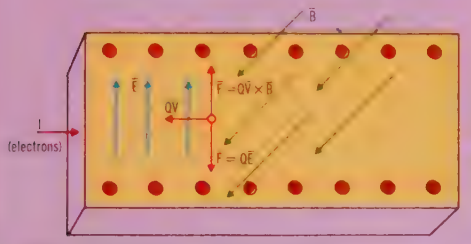


Fig. 2. Explanation of the Hall effect.

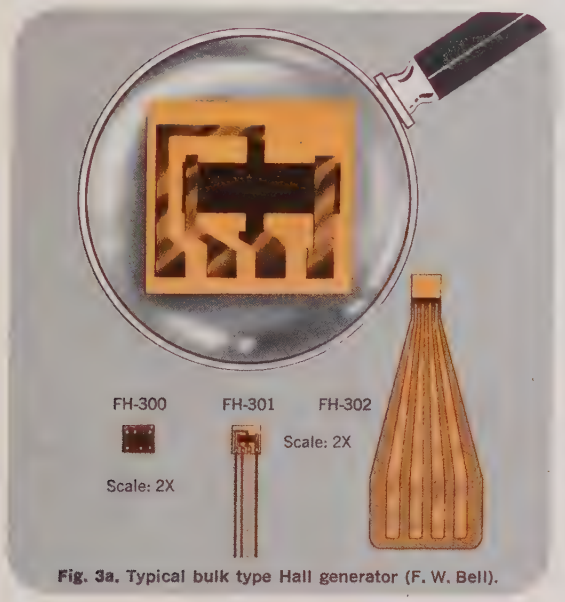


Fig. 3a. Typical bulk type Hall generator (F. W. Bell).

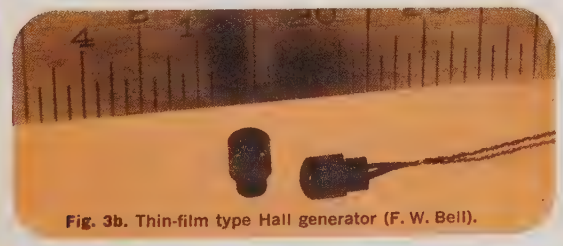


Fig. 3b. Thin-film type Hall generator (F. W. Bell).

E. H. Hall, while investigating magnetic forces on a current carrying conductor, discovered that a magnetic field would skew the equipotential lines in the conductor. This effect is observed as an induced voltage (Hall voltage, V_H) perpendicular to the direction of current in the conductor (Fig. 1).

The action of the Hall effect in a semiconducting medium is adequately explained by quantum physics, However, in spite of its shortcomings, the classical approach is chosen here for its brevity.

A particle with charge, Q, velocity, $\bar{V}$, and moving within a magnetic field, $\bar{B}$, will experience the Lorentz force, $\bar{F} = Q(\bar{V} \times \bar{B})$. The force direction is mutually perpendicular to the directions of the particle velocity and the magnetic field. If a long, flat current-carrying conductor is placed in a magnetic field, the moving charges will experience a net force mutually perpendicular to the direction of the current flow (longitudinal conductor axis) and the magnetic field. Under the influence of this force, the electrons will "pile up" on one edge of the conductor, and positive charges will gather on the other edge. An uneven lateral charge distribution results and gives rise to an electric field, $\bar{E}$, which exerts a force, $\bar{F} = Q\bar{E}$, opposite in direction to the Lorentz force. At equilibrium, the resultant forces balance (Fig. 2). This field, superimposed on the $\bar{E}$ field in the direction of the current flow, yields the skewed equipotential lines first noted by Hall (Fig. 1). The relation between the voltage, current, and magnetic field can be generalized as follows:

$$V_H = \gamma IB \qquad (1)$$

where V_H = Hall voltage
γ = a constant product sensitivity
I = Hall current
B = magnetic field perpendicular to the Hall plate surface

This equation ignores many low level effects but will suffice for the depth of this discussion.

Hall generators can be classified in two types, according to the method of manufacture (Fig. 3). Bulk Hall generators are made from carefully prepared slices of semiconductor material cut from a large ingot. Hall plates of the desired dimensions are made from these slices. The plates are bonded to a substrate, and the two current voltage contacts are made. This type of Hall generator is usually epoxy encapsulated for protection. Thin-film Hall generators are made by material deposition techniques. The semiconductor and conductor patterns are fabricated with the same photo techniques used in IC manufacturing. Bulk Hall generators usually require more current, possess better linearity characteristics, and exhibit lower product sensitivity than the thin-film type. Both are used in applications that require their respective distinctive features.

Note: All $\bar{B}$ fields in the article refer to the component of the external $\bar{B}$ field that is normal to the surface of the Hall plate. A more general equation for Hall voltage is $V_H = \gamma IB \cos\theta$, where θ is the angle between B and the normal to the Hall plate surface.

Engineering Silectron core. Since its saturation level is approximately 12 kG, the maximum allowable flux density in the gap is 6 kG (to prevent saturation).

Apply Eq. 3 to calculate minimum sensitivity:

$$\gamma_B = V_H/B = 60/6 = 10 \text{ mv/kG}$$

Since Hall devices are available with sensitivities near this, it is a reasonable figure.

Next, check to see how large the core gap must be. Using equation 2:

$$l_g = NI/2B - 150/(2)\ (6) = 12.5 \text{ mils} = 0.0125''.$$

The flux density is a maximum for this dimension; therefore 12.5 mils is the minimum gap size for measuring the 150 amperes. Most Hall generators do not fit in a 12.5 mil gap and a larger gap will probably be required. Enlarging the gap reduces the flux density and decreases the Hall output level. The next step is to consult Eq. 4 and Hall generator specification sheets to select a Hall generator with a sensitivity greater than the calculated 10 mv/kG.

Assume a Hall generator is used with a sensitivity of 50 mv/kG instead of 10 mv/kG. The proper gap size can be determined from the specifications for that particular Hall generator. Then Eq. 2, can be used to check the gap flux density to determine if it exceeds one-half the core saturation level. The corresponding output voltage calculated from Eq. 3 should be at least the desired 60 mv.

As an example, assume the Hall generator is an F. W. Bell BH-700. Its sensitivity is 50 mv/kG, and it is normally mounted in a 30 mil gap. Using equation 2:

$$B = NI/2l_g = 150/60 = 2.5 \text{ kG}$$

This is a permissible gap flux density. Using equation 3:

$$V_H = B\gamma_B = 2.5\ (50) = 125 \text{ mv}$$

This voltage will satisfy the voltage requirement.

When choosing a Hall generator with the desired sensitivity, consider the required control current (low current models are available), accuracy, linearity, reliability, and cost. Special requirements may affect the choice. For example, low current measurements ($<$ 10 amperes) require a small gap. The Bell Model BH-702 has a ferrite substrate that can reduce the effective gap length to 3 mils (0.003"). Nonferrous spacers of the proper thickness are useful in maintaining gap size. The Hall generator is either floated in the gap with Dow Corning Sylgard 186 (or a similar material) or held rigidly to one of the pole faces by an epoxy resin.

It is advisable to test and optimize the performance of a current sensor by varying gap length, Hall generator control current, and core material.

Multiplying with the Hall

As multipliers, Hall effect devices are used in a great variety of applications, such as suppressed carriers and a-m modulation, linear and square-low demodulation, level control, phase detection, the generation of various functions, and analog computation.

A Hall multiplier (Fig. 4), consists basically of a core and coils with an air gap in the flux path. A Hall generator, positioned in the gap with appropriate mechanical protection and shielding, provides the actual multiplication of the two input currents I_f and I_c. The output is a voltage proportional to this product, as given by Eq. 1 ($V_H = \gamma IB$). The magnetic field, B, must be proportional to input field current, I_f, to satisfy this relation. In practice, the accuracy and linearity of the multiplication depends ultimately on the ability to deliver into the multiplier, currents that are proportionally related to the desired input parameters. The Hall input is essentially a pure resistance, so it presents no problem to the required current proportionality. The coil input, on the other hand, has an inductive impedance plus some resistance. In a-c applications, the change in current due to varying impedance with frequency can be overcome by the use of a series swamping resistor or by feeding from an amplifier with output current feedback.

Many different functions can be generated by using a Hall multiplier. The inputs can be a-c, d-c, or a mixture of both.

Modulates with no low frequency limit

As a linear-product modulator, a Hall multiplier eliminates undesired distortion terms that appear when nonlinear elements are used. Supplied with a carrier reference signal, it functions as a synchronous, linear demodulator of both conventional a-m or suppressed carrier a-m signals.

One of the greatest potential applications for the Hall multiplier is in the carrier-type d-c or low frequency amplifier (Fig. 5). Modulation and demodulation are carried out at the carrier amplifier input and output respectively. A local oscillator provides the carrier signal for both modulation and demodulation. Extremely stable, high-gain, drift-free d-c amplifiers are thus possible.

Since a Hall modulator-demodulator system has no low frequency limit, it is an attractive means of low frequency measurement. Precise frequency comparison by the zero-beat method can be made by careful phase rate measurements of the difference signal or by axis cross-over time measurements. — *E/A*

Reprinted From ELECTRONIC PRODUCTS Magazine — September 18, 1972 Issue
645 Stewart Ave., Garden City, N. Y. 11530 • © 1972 United Technical Publications, Div. of Cox Broadcasting Corp. PRINTED IN U.S.A.

ADDENDA

"The Hall effect comes into its own."

page 1, paragraph 1, sentence 3:

However, semiconductor technology has recently developed new materials that exhibit Hall voltages three or four orders of magnitude (1000 to 10,000 times) greater than that of metals, and the new type of Hall devices are conquering all kinds of application areas, from the ocean depths to the orbiting satellites.

page 2, column 2:

γ_B = magnetic sensitivity of the Hall devices in mV/kG.

page 3, Figures 3a and 3b titles:

Fig. 3a Thin-film type Hall generators (F.W. Bell, Inc.)

Fig. 3b Typical bulk type Hall generator (F. W. Bell, Inc.)

"Temperature compensating Hall generators"

page 1, column 3, after the heading "Sensitivity Variation":

The relation of electron mobility to temperature causes Hall generator sensitivity to decrease as temperature increases.

page 2, column 3, paragraph 3, sentences 3 & 4:

Units with V_{MT} between 100 and 500 μV normally exhibit an increase in residual voltage magnitude, but at rates varying within ±100% of the resistive coefficient. Below 100 μV, the task of predicting the offset drift becomes difficult because the direction and rate are random.

Subject: USING AN F. W. BELL HALL GENERATOR

No. H-100

CAUTION! To avoid possible permanent damage to the Hall generator, please read the following instructions carefully before making connections to a power supply.

INTRODUCTION

A Hall generator is a four-terminal, solid-state device capable of producing an output voltage, V_H, proportional to the product of the input current, I_C, the magnetic flux density, B, and the sine of the angle between B and the plane of the Hall generator.

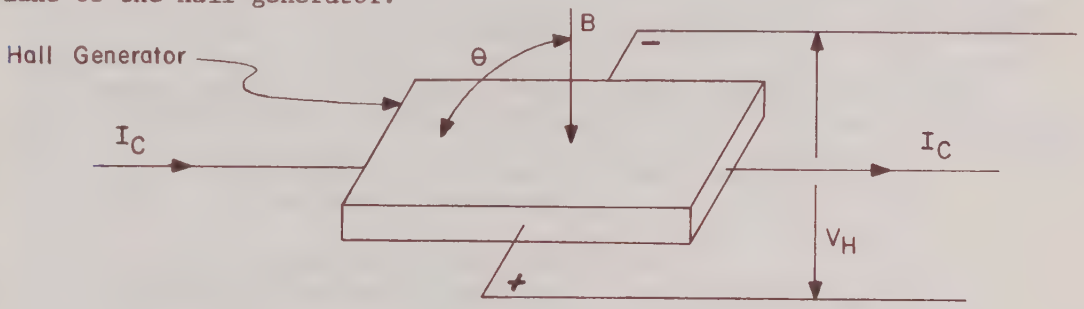


Figure No. 1

$V_H = K_{HOC}\ I_C\ B \sin\theta$
or if $\sin\theta = 1$ (i.e. $\theta = 90°$)
$V_H = K_{HOC}\ I_C\ B$ or $V_H = \gamma_B\ B$

where:
V_H = Hall output voltage, mV
$K_{HOC} = \gamma_{IB}$ (open circuit product sensitivity constant), mV/mA **kG.**
γ_B = magnetic sensitivity (loaded or unloaded) at a specified control current, mV/**kG.**
I_C = control current, mA **(ac or dc)**
B = magnetic flux density, **kG (ac or dc)**

A reversal in the direction of either the magnetic field or the control current will result in a polarity change of V_H. A reversal in the direction of both will keep the polarity the same. By holding the control current constant, the Hall voltage may be used to measure magnetic flux density. Multiplication may be accomplished by varying both the control current and the magnetic field. For more information on Hall effect theory and applications, refer to the booklet "The Hall Effect and Its Applications", available at no charge from F. W. Bell, Inc.

-OVER-

6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

CONNECTING THE HALL GENERATOR

The following schematic diagram illustrates the proper connections for the Hall generator:

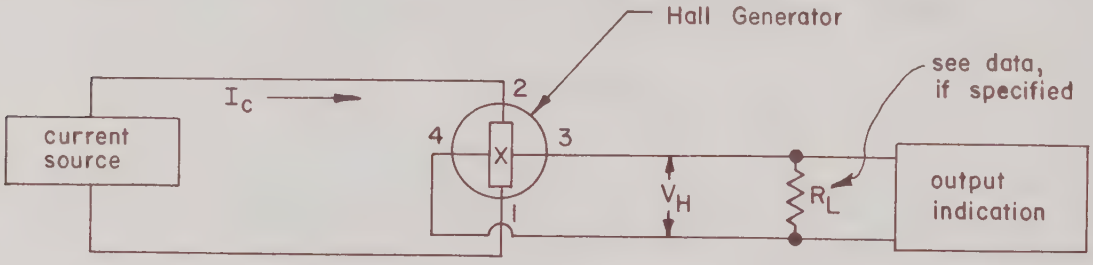


Figure No. 2 Hall Generator Circuit Configuration

Lead connections: 1 and 2 are control current leads
3 and 4 are Hall voltage leads

Color Code: AWG 34 red ($+I_C$), black ($-I_C$)
blue ($+V_H$), yellow ($-V_H$)

AWG 36 neutral ($+I_C$), green ($-I_C$)
red ($+V_H$), neutral ($-V_H$)

Refer to the Hall generator specification sheet for the AWG size of the leads. If a loading resistor R_L is specified, then it must be added to the output circuit as shown above to obtain the specified output.

Current Source

A constant current supply is recommended for applications requiring fixed control current. This eliminates effects of input resistance changes resulting from temperature or field variations (magnetoresistance effect). A "brute-force" constant current source may be made by connecting a large resistor (30 times R_{IN} or higher) in series with a battery or constant voltage power supply. In any case, the short-circuit current should be within the maximum current rating of the Hall generator. The control current may be either AC or DC. This is determined by the nature of the field and the type of output signal desired.

Output Indicator

The Hall output voltage, V_H, may be observed on any suitable instrument such as a millivolt meter, oscilloscope, or recorder. The input impedance of the instrument should be greater than approximately 1000 ohms.

C A U T I O N ! I S O L A T I O N R E Q U I R E D !

Since the four Hall generator leads connect to four points on a semiconductor plate having different potentials, no two leads can be connected together without upsetting the operation. Therefore, the current source and the output indicator cannot have a common connection, but must be isolated from each other. One or the other, but not both, may be grounded.

Misalignment (Null) Voltage Compensation

In the manufacturing of the Hall generator, the Hall voltage contacts are placed on the semiconductor plate as accurately as possible so that very little output voltage will exist when there is no magnetic field present. For many applications, this resistive null voltage is low enough to be neglected, but for low field applications, it may be appreciable compared to the Hall output voltage, V_H. If this is the case, a null voltage balancing network such as that in Figure 3 will make it possible to reduce the resistive null voltage to zero. The fine control may not be required.

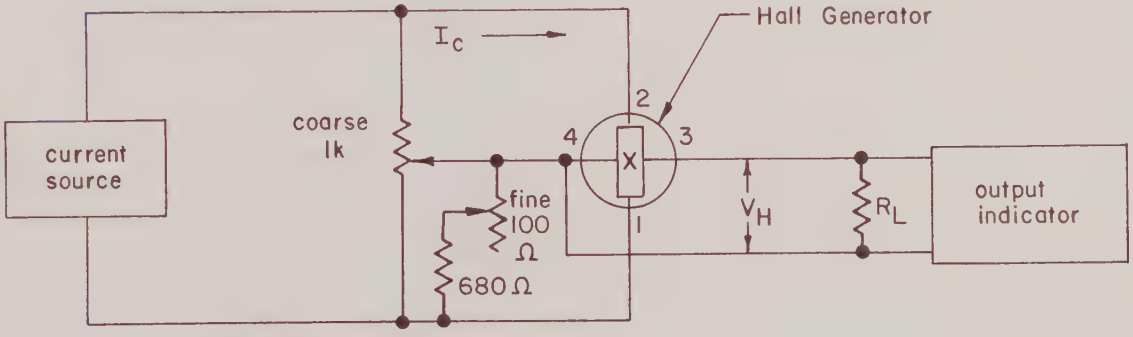


Figure No. 3 **Misalignment (Null) Voltage Compensating Network**

-OVER-

Affects of Residual Magnetism

Care should be taken to ensure that what appears to be an offset voltage of the Hall generator is not really the result of a residual magnetic field. Any magnetic material with a residual field in close proximity of the Hall generator could effect a slight Hall output voltage, V_H. Items such as fixtures, jigs, probes, metal tables, metal cabinets, etc., are potential sources of residual magnetic fields. Even the earth's magnetic field (approximately 1/2 gauss) could cause an undesirable "offset" voltage. The circuit in Figure 3 can be used to zero out many of these voltages.

SPECIAL APPLICATIONS

Additional information on specific applications of Hall generators may be obtained by writing or calling F. W. Bell, Inc.

NEW ADDRESS
6120 HANGING MOSS RD.
ORLANDO, FLORIDA 32807
(305) 678-6900

F.W. BELL

TECHNICAL BULLETIN

Subject: HALL GENERATOR MOUNTING **No.** H-101

handling

The Hall generator is fragile. It cannot be handled the same way most other electronic components are handled. The aluminum oxide substrate is brittle and very sensitive to bending stress. Use the leads to move and locate it. Do not handle the substrate. The lead to substrate bond strength is on the order of several ounces. Avoid tension on the leads and avoid bending them close to the substrate. The leads may be bent at any angle as long as the bend is at least ⅛″ away from the substrate connection.

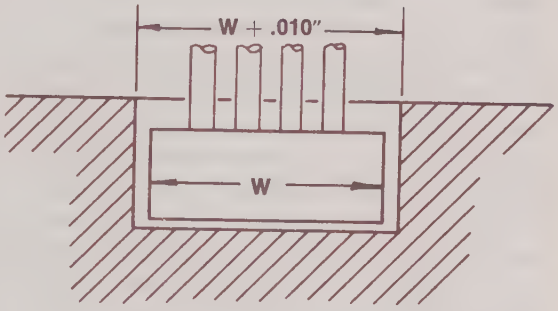
slot mounting

The preferred mounting procedure is to locate the chip in a slot that is any depth, .003 inch wider and .010 inch longer than the substrate. Tack the leads outside the slot with Sylgard 186* or a similar substance. Don't get Sylgard 186* inside the slot. If an extreme temperature range is expected, check the coefficients of thermal expansion to be certain that the slot will always have clearance for the chip. This procedure is not recommended for installations that will be subject to any acceleration greater than 10 G.

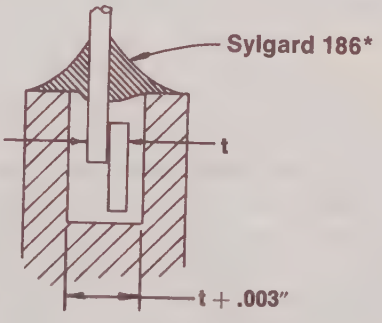
surface mounting

Surface mounting is acceptable when necessary. The mounting surface may be any non-flexible solid with a flat, smooth (±.001″) surface at least the size of the substrate. The substrate

slot mounting



front view



side view

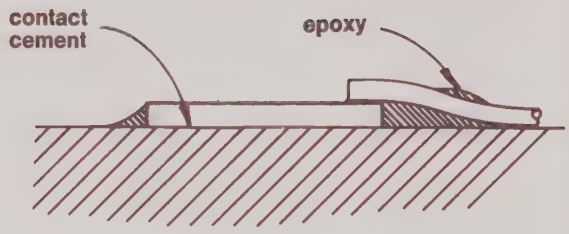
*Product of the Dow Corning Corporation

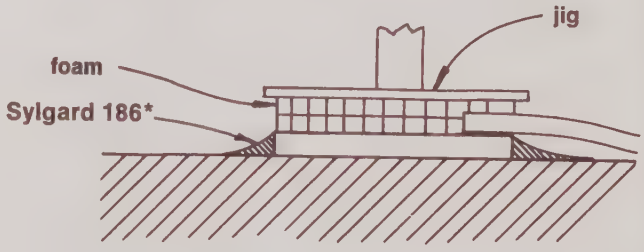
6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

must not overhang the mounting surface. Steel, ferrite, ceramic, and glass are examples of mounting surfaces. For extended temperature ranges, choose a material with a coefficient of thermal expansion no greater than a factor of three different from that of the aluminum oxide substrate ($\cong 7 \times 10^{-6} \frac{IN}{IN°C}$). For a permanent mount, sparingly coat the mounting surface with Eastman 910 contact cement or other similar cement. The ceramic side of the substrate is visible as non-red or as opposite the Hall element. Locate the ceramic side on the clean, degreased surface and apply extremely light pressure with a foam pad until the bond is made. Wipe off the excess contact cement. Use an epoxy such as Bacon Industries FA8 or Emerson and Cuming 2850FT to form a fillet around the plate and to secure the leads. Don't get epoxy on top of the chip. If encapsulation is absolutely necessary use a light coating of Sylgard 186* or a similar soft material.

For a non-permanent surface mount, secure the substrate against the surface with a foam padded mounting jig. The jig should apply only light pressure. Fillet the plate and secure the leads with Sylgard 186* or a similar material.

surface mounting





test

After the Hall generator has been mounted, check the misalignment voltage per the proper specification. A large misalignment voltage shift (100 μV or more) is a sign of Hall generator physical damage.

*Product of the Dow Corning Corporation

Subject: Temperature Compensating Hall Generators

No H-102

by J. A. Dierker
F. W. Bell, Inc.

Temperature effects can rarely be ignored in the application of a Hall generator. Selecting a generator with a low temperature coefficient of sensitivity may suffice, but compensation is often required. If the designer understands the parameters involved, their effects on the Hall device output, and knows the ambient operating conditions, applying the compensating networks is simple. Due to the wide range of parameter variations among Hall generators of the same type, however, it is difficult to have one compensation network work for all generators that are used.

The compensation circuits offered below represent the basics; the total possibilities are limited only by the user's imagination. Only N-type indium arsenide Hall generators will be considered. Conduction is by majority carriers, no semiconductor junctions exist, and all contacts to the semiconductor material are ohmic.

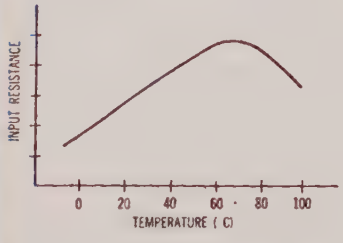


Fig. 1. "Worst case" temperature characteristics of input resistance.

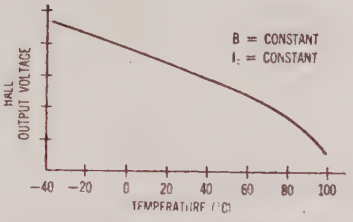


Fig. 2. The sensitivity of a Hall generator decreases with temperature.

An indium arsenide Hall generator usually exhibits a positive temperature coefficient of resistance (α_T) over its normal operating range. If a constant voltage supply provides the generator control current, this current decreases as the Hall plate temperature increases. The result is an output sensitivity inversely related to temperature. A constant current supply eliminates the effects of Hall generator input resistance changes. This condition can also be approximated by a voltage supply with high output impedance. If conditions require a low-impedance voltage supply, the designer who wants to compensate for α_T must be aware of a sign reversal on it, as shown in Fig. 1.

For most Hall generators with product sensitivities below 0.2 volts per ampere kilogauss, the sign change on α_T takes place at temperatures above the normal operating range. In this case, the compensating networks discussed in the following sections may be used. Higher sensitivity devices exhibit the sign reversal within their operation range, however (see Fig. 1). This behavior can make compensation very difficult, and the designer may have to accept the input resistance temperature effect or change to a higher source impedance.

Sensitivity variation

The relation of electron mobility to temperature causes Hall generator sensitivity to decrease as temperature increases. This phenomenon is independent of the temperature coefficient of resistance effect. Normally, Hall generators with higher sensitivities exhibit higher temperature coefficients of sensitivity (β_T) at constant current. The output variation is approximately linear from −60° to 60° C. Above 60°C, the rate of change increases rapidly (see Fig. 2)

Several methods of compensating for temperature variation of the parameters discussed above exist. Since all the suggested procedures require trial-and-error calculations and testing, only the overall configuration is described.

A positive temperature coefficient (PTC) resistor can be used as a compensating element (Fig. 3). Nickel or copper wire resistance are possibilities, or PTC silicon resistors may be considered. Nickel exhibits a positive temperature coefficient of about 0.5%/°C; copper, 0.4%/°C; and silicon resistors, about 0.7%/°C.

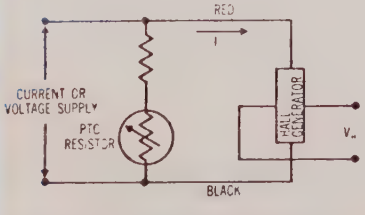


Fig. 3. A positive temperature coefficient thermistor can be used in temperature compensation of Hall generators.

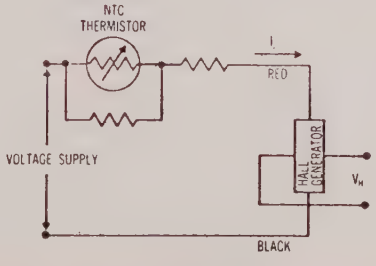


Fig. 4. A Hall generator can be compensated at its input by a negative temperature coefficient thermistor.

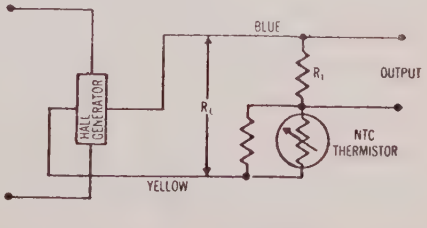


Fig. 5. Temperature compensation of a Hall generator using a negative temperature coefficient thermistor.

Negative temperature coefficient (NTC) thermistors are the most widely used devices for compensating Hall generator temperature drift (Fig. 4). This configuration with a voltage supply causes the control current, I_C, to increase as the temperature rises.

Another compensation method using an NTC thermistor is shown in Fig. 5. In implementing this concept, the designer must make sure that two conditions exist. Ample output must be maintained across resistor R_1, and the total load, R_L, presented to the Hall generator must not adversely affect output linearity. (Consult the Hall generator manufacturer if linearity is a critical parameter.) If amplification is required, an alternative to the circuit in Fig. 5 would be to place a thermistor circuit in the feedback network of the amplifier.

Single thermistor or PTC resistor circuits usually exhibit good high-temperature correction, or vice versa. Improved compensation over a wider temperature range may be achieved through use of two temperature sensor networks. The two may be a combination of those mentioned above.

The following example (Fig. 6) illustrates the results of negative temperature coefficient thermistor compensation in the Hall generator input circuit. The Hall generator has the characteristics listed below:

Input Resistance (R_{in}), 4Ω

Magnetic Sensitivity (γ_B), 30 mv/kg (At I_C = 100 ma and T = 25°C)

Temperature Coefficient of Input Resistance (α_T), +0.2%/°C

Temp. Coefficient of Magnetic Sensitivity (β_T), −0.22%/°C

Improved Hall generator temperature drift is desired between 25° and 60°C. Uncompensated, the generator sensitivity at 60°C would decrease approximately 8% from its value at 25°C. A first attempt to improve this temperature drift might be the circuit shown in Fig. 6B. The real problem is to select proper values for R_1 and R_T.

Increasing the Hall generator control current by about 8% at 60°C will eliminate the drop in sensitivity due to β_T. The next step is to calculate a thermistor-resistor parallel resistance, R_{TOT}, which will supply 108 ma control current at 60°C. (Changes in resistor R_1 and in the Hall generator input resistance are small and will be ignored throughout this example).

$$R_{TOT} = (V_S/I_C) - R_{in}$$
$$= 5/(0.108) - 4 \cong 42.3\Omega$$

Since thermistor resistance will be selected at 60°C, R_T will generally be high in value at 25°C. Assuming that R_T will be moderately high, let R_1 be 47Ω. If our assumptions are correct, the Hall generator control current will be near 100 ma at 25°C. Next, the thermistor resistance at 60°C must be calculated:

$$R_T = \frac{R_1\,(R_{TOT})}{R_1 - R_{TOT}}$$

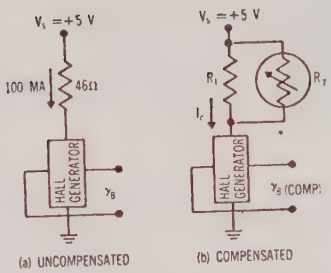


Fig. 6. The use of a negative temperature coefficient thermistor as a compensator in the Hall generator input.

T (°C)	γ_B (mv/kg)	R_T (Ω)	R_{TOT} (Ω)	I_C (ma)	γ_B (Comp.) (mv/Kg)
−10	32.3	6447	46.66	98.7	31.88
+10	31.0	2636	46.18	99.6	30.88
+25	30.0	1440	45.51	101.0	30.30
+40	29.0	827	44.47	103.2	29.93
+60	27.7	423	42.30	108.0	29.92

Test results on sensitivity with compensated and uncompensated circuits.

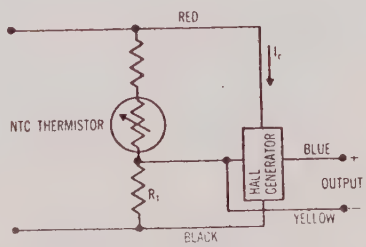


Fig. 7. Compensation of zero field residual voltage temperature drift of Hall generators.

The table below gives a comparison of sensitivity change for both the uncompensated and compensated circuits (a thermistor temperature coefficient of −3.9%/°C was used). A higher R_1 might be selected for better low-temperature response.

Zero field residual voltage

In most cases, the zero field residual voltage (V_{MT}) temperature drift is separate, but not distinguishable, from sensitivity drift. When magnetic flux densities are high, the effect of V_{MT} temperature drift may be negligible. In situations of low magnetic field, the temperature drift of the residual voltage may be equal to or larger than the sensitivity change. The inability to consistently and accurately predict the rate and direction of drift in this offset voltage is the most difficult part of compensation.

Since the major portion of the V_{MT} is caused by unbalanced output contact positioning (misalignment voltage), the characteristics of the temperature drift may be predicted with fair accuracy. For devices with a room temperature V_{MT} greater than 500 μv, the magnitude of the zero field residual voltage increases at a rate approximately equal to the temperature coefficient of resistance, α_1. Units with V_{MT} between 100 and 500 μV normally exhibit an increase in residual voltage magnitude, but at rates varying within ±100% of the resistive coefficient. Below 100 μV, the task of predicting the offset drift becomes difficult because the direction and rate are random. A circuit that can be used to compensate for the zero field residual voltage temperature drift is shown in Fig. 7.

The thermistor shown compensates for a positive-going temperature drift (with respect to the output terminals). If the zero field residual voltage varies negatively with increasing temperature, the thermistor network and R_1 must be interchanged.

Bibliography

H. Weiss, *Structure and Application of Galvanomagnetic Devices*, Pergamon Press.

H. H. Wieder, *Hall Generators and Magnetoresistors*, Pion Limited.

MIL-STD-793-1 (WP) "Definitions, Letter Symbols, Color Code and Circuit Symbol for Devices, Hall Effect."

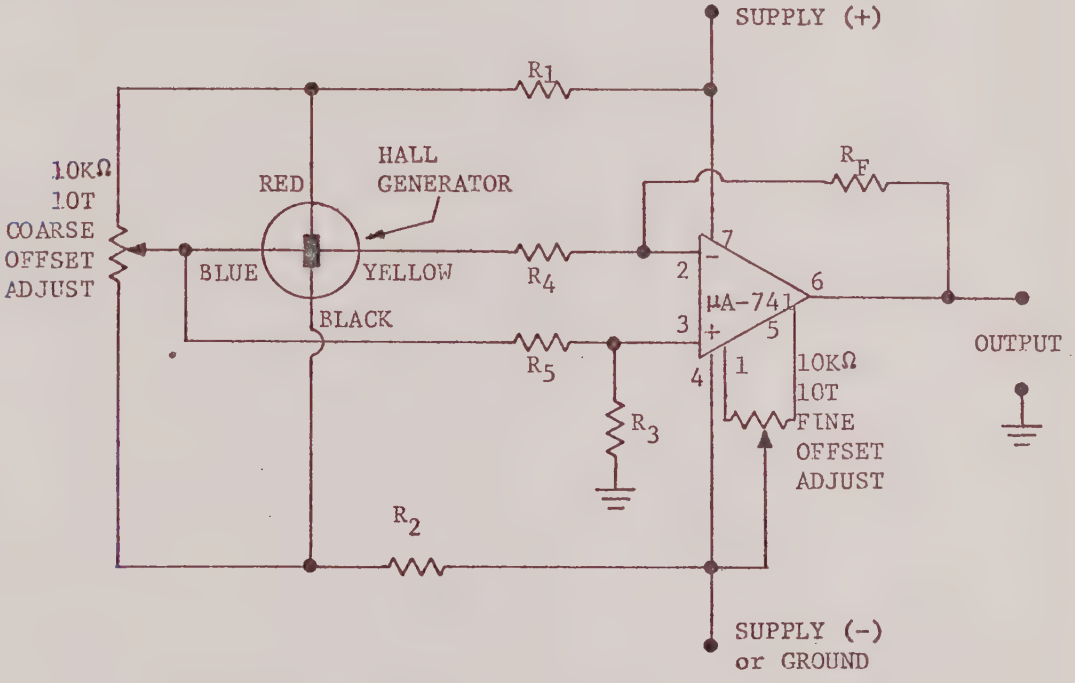
Reprinted from Electronic Products Magazine, May 21, 1973, 645 Stewart Avenue, Garden City, New York 11530, 1975 United Technical Publications, Inc., a division of Cox Broadcasting Corporation.

F.W. BELL

TECHNICAL BULLETIN

Subject: HALL GENERATOR AMPLIFIER CIRCUIT **No.** H-103

Below is a schematic for a simple, low cost, linear amplifier for the output voltage of an F. W. Bell, Inc. Hall generator. The amplifier will provide moderate performance at a fixed gain.



$R_1 = R_2$: Selected for desired Hall generator control current

R_4 & R_F: Feedback resistors selected for desired gain

$R_4 = R_5$ $R_3 = R_F$

Frequency response: D.C. to 10 kHz

The semiconductor systems described herein are intended only to illustrate typical applications. The information is believed reliable; however, no responsibility is assumed for inaccuracies.

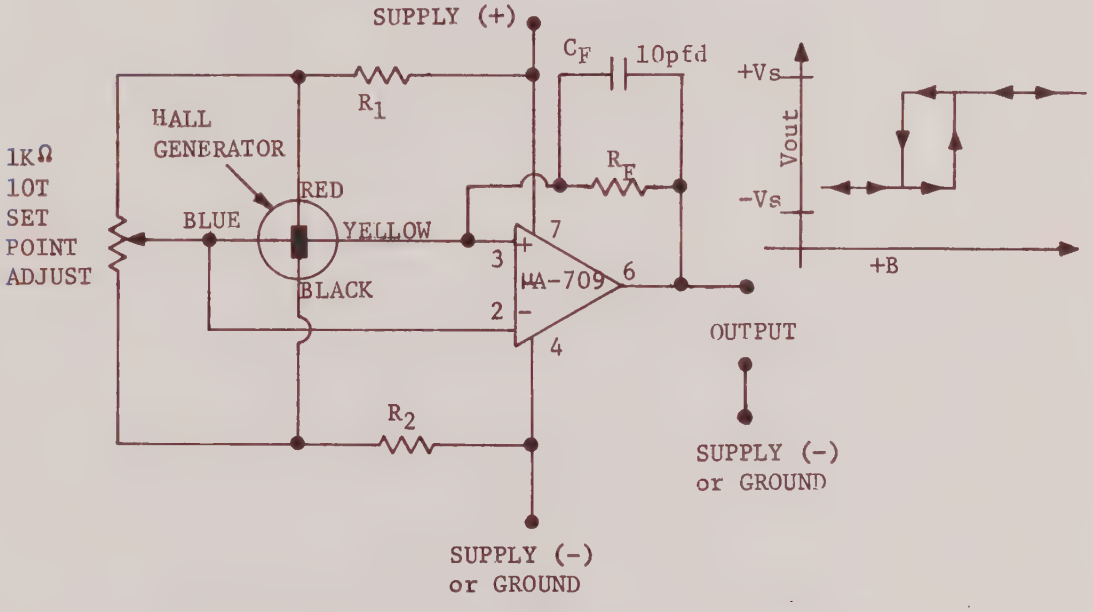
6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

F.W. BELL

TECHNICAL BULLETIN

Subject: HALL GENERATOR SWITCHING CIRCUIT **No.** H-104

Below is a schematic for a simple, low cost switching circuit for use with an F.W. Bell, Inc. Hall generator. The circuit is triggered by the output voltage of the Hall generator and the point at which the circuit is triggered is variable. The amplitude of the circuit's output voltage is approximately (2) (Vs)-2V.



$R_1 = R_2$: Selected for desired Hall generator control current

R_F: Feedback resistor selected for the required hysteresis. Typical value is 100Ω

Frequency response: D.C. to 10 kHz

The semiconductor systems described herein are intended only to illustrate typical applications. The information is believed reliable; however, no responsibility is assumed for inaccuracies.

6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

Subject: HALL GENERATOR TEST PROCEDURE **No.** H-105

Refer to the schematic on the reverse side.

(1) TEST CURRENT CALIBRATION

With switch S-1 in the "Cal" position, adjust the constant current supply output until the dc voltmeter reads 100 mV*(or 10 mV**). The test current is now calibrated at 100 mA* (or 10 mA**).

(2) INPUT RESISTANCE MEASUREMENT

Place the test Hall generator leads in the proper "Kelvin Klips". Move switch S-1 to the "Rin" position. The reading on the voltmeter in millivolts, divided by 100* (or 10**), is the value of the input resistance.

(3) OUTPUT RESISTANCE MEASUREMENT

Same procedure as input resistance except readings taken with S-1 in position 3.

(4) ZERO FIELD RESIDUAL VOLTAGE

With the Hall generator still in the "Kelvin Klips", move the selector switch to the "V_H" position. Place the Hall generator active area into a zero gauss chamber, F. W. Bell Model YA-111. The zero field residual voltage at a control current of 100 mA* (or 10 mA**) is read directly on the dc voltmeter.

The value at higher control currents can be calculated from the fact that the zero field residual voltage is directly proportional to the control current. If desired, the control current may be recalibrated, as in step 1, to the desired value prior to reading zero field residual voltage.

(5) MAGNETIC SENSITIVITY MEASUREMENT

Remember or record the polarity and value of the zero field residual voltage.

Place the Hall generator in a known magnetic field (1 kilogauss is convenient) with the red surface towards the north pole of the magnet. Subtract algerbraically the zero field residual voltage from the field generated reading. This gives the output voltage swing. Dividing the voltage swing by the field value gives the magnetic sensitivity of the Hall generator at the calibrated test current.

When tests are complete move S-1 to the "Cal" position, then remove the Hall generator.

* Values for testing BH-Series Hall generators
** Values for testing FH-Series Hall generators

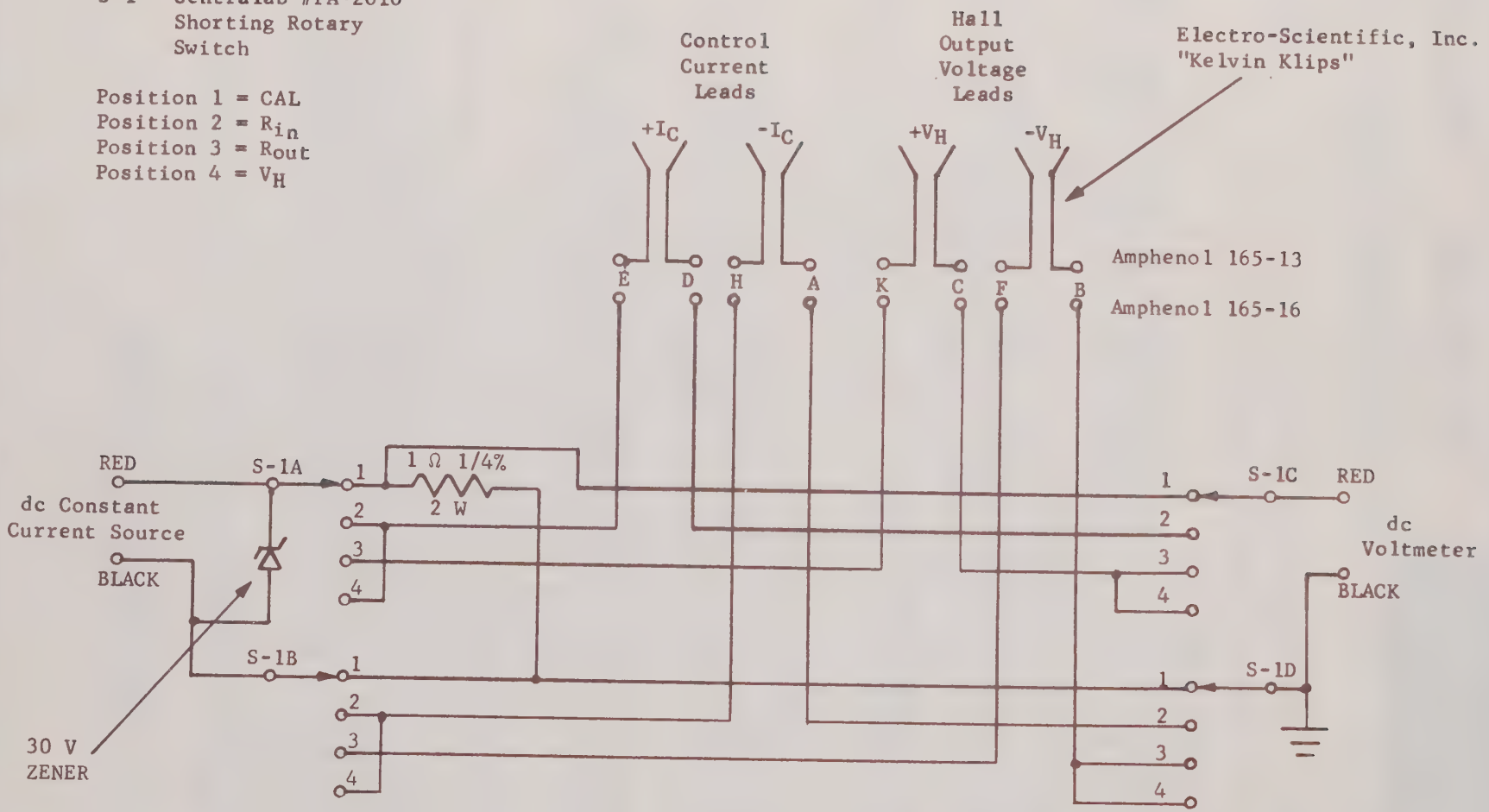
August 1977

-over-

6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

S-1 = Centralab #PA-2010
Shorting Rotary
Switch

Position 1 = CAL
Position 2 = R_{in}
Position 3 = R_{out}
Position 4 = V_H



Majestic Industries Inc
Teterboro, N. J.

MAGNET PROCESSING EQUIPMENT

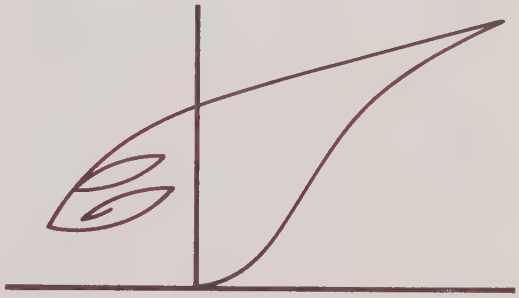
GENERAL DESCRIPTION

The F. W. Bell line of magnet processing equipment consists of magnetizers, stabilizers and fixtures designed to magnetize and stabilize permanent magnets. Each unit is solid state and reflects the expertise of Bell's experienced engineering staff. Bell equipment is dependable and has extremely low maintenance requirements.

Bell **magnetizers** are capacitive discharge power units designed to supply a current pulse to a magnetizing fixture coil. The energy level is variable and accurately repeatable. Internal logic makes it impossible to fire the magnetizer until the capacitor-stored energy reaches the preset level. The use of high reliability SCR's and other high quality components insures that Bell magnetizers will operate continuously within their specifications.

Bell **stabilizers** are phase-fired SCR power units designed to supply the demagnetizing current to a fixture coil. The magnitude of the current is variable, repeatable and may be controlled automatically for field stabilization purposes. The unit will supply enough current to a properly designed coil and fixture to stabilize most modern magnetic materials.

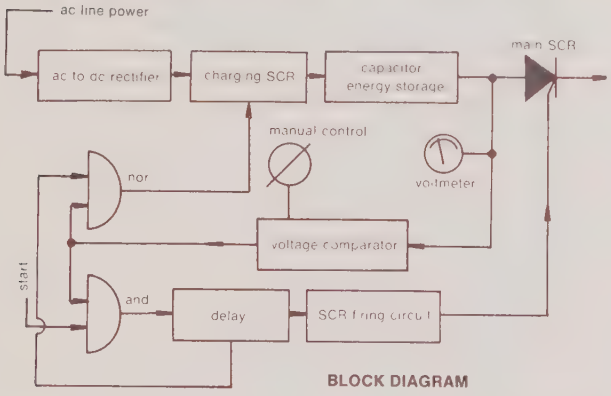
Bell **fixtures** are designed to apply the proper pulsed magnetic field to the magnet or magnet assembly. The fixtures provide the field shape and direction to accommodate the specific magnet configuration and magnetization direction. Special fixtures that simulate specific magnetic circuits are available. F. W. Bell supplies fixture design assistance.



FEATURES

- **Solid State**
  The entirely solid state units are designed for long life and high reliability.
- **Low Voltage Magnetizer**
  The magnetizer operates at high capacity and low voltage for personal safety and long equipment life.
- **Manual or Automatic Operation**
  Magnetizer and stabilizer units are usually manually operated. However, they may be integrated into automatic systems through the use of optional equipment available from F. W. Bell.

magnetizers



BLOCK DIAGRAM

FUNCTIONAL DESCRIPTION

The ac line voltage is stepped up, rectified and applied to the charging SCR in series with the capacitor bank. A voltage comparator allows the SCR to conduct and charge the capacitors until the voltage reaches the preset level. The comparitor then maintains the capacitor voltage until the firing SCR is triggered.

The magnetize button first holds the charging SCR off, then triggers the firing SCR. The capacitor-stored energy is supplied to the fixture through the magnetizer output. After a delay the charging SCR is permitted to turn on and the charging cycle starts again.

MAGNETIZER SPECIFICATIONS

model number	energy maximum	storage voltage	storage capacity	charging time to 100V	charging time to 200V	charging time to 275V	charging time to 350V	peak magnetizing current	cabinet size
860	600 watt-sec	35 V to 350 V	10,000 μF	1s	2s	3s	7s	6 kA	19.75" W 501.65 mm 14.75" H 374.65 mm 18.06" D 458.72 mm
861								12 kA	
860A	1200 watt-sec		20,000 μF	1.5s	2.5s	5s	12s	6 kA	
861A								12 kA	
870	1800 watt-sec		30,000 μF	1.5s	3s	9s	20s	6 kA	19.75" W 501.65 mm 21.75" H 552.45 mm 18.06" D 458.72 mm
871								12 kA	
870A	3000 watt-sec		50,000 μF	2s	4s	12s	30s	6 kA	
871A								12 kA	

Rack mount units available—consult factory for model numbers and specifications.

common specifications

Inputs: control connector on rear, for remote firing

Outputs: magnetize complete, (logic output) system ready lamp, (indicates when capacitors are at the preset voltage) current shunt, 0.1 mV/A proportional (to measure the charging current)

Operation: manual or automatic with magnetizer control module

Weight: approx. 130 lb. (59.09 kg)

Shipping weight: approx. 180 lb. (81.81 kg)

Power: 117 Vac, 15 A, 60 Hz or 234 Vac, 7.5 A, 50 Hz (Customer to Specify)

See back page for stabilizer information

fixtures

GENERAL DESCRIPTION

The magnetizing fixture transforms the capacitor stored energy (discharged as a current) into magnetizing energy (a pulsed magnetic field.) Fixtures are designed to provide the field shape, direction, and intensity to accommodate a specific magnet. Fixtures that simulate certain magnetic circuits are available. Both air-core and iron-core fixtures are commonly used. F. W. Bell has the experience and expertise to offer design assistance.

MODEL C-604

A general purpose air core fixture designed for use with Bell magnetizers. It is completely encapsulated in high temperature epoxy.

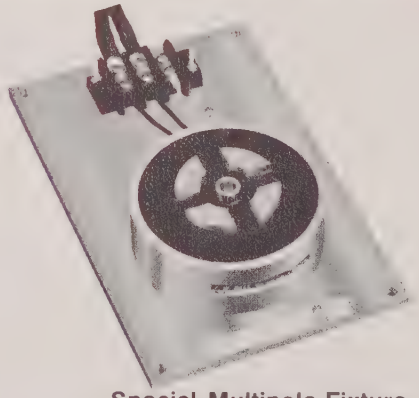
STANDARD FIXTURE MODELS (AIR CORE)

	model C-601A	model C-602	model C-603	model C-604
max. peak field (typical)	25.5 kOe	16.0 kOe	11.4 kOe	7.5 kOe
peak current at max. field	3200 A at 300 V	1400 A at 300 V	2100 A at 300 V	2000 A at 300 V
max. operating temperature	85°C	85°C	85°C	85°C
aperture diameter	1 0" (25 4 mm)	1.63" (41.40 mm)	2.5" (63.5 mm)	3.5" (88.9 mm)
aperture depth	. 1.5" (38.1 mm)	1.5" (38.1 mm)	2.25" (57.15 mm)	2.25" (57.15 mm)

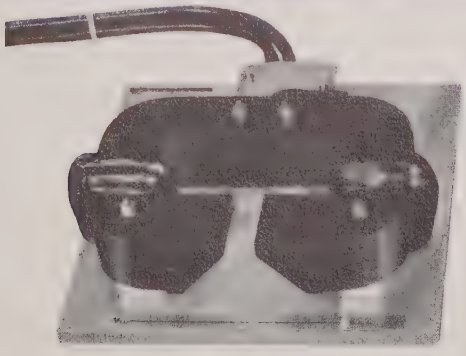
TYPICAL CUSTOM DESIGNED AND BUILT FIXTURES

F. W. Bell engineers will fabricate fixtures to your specifications, or will handle all elements from design through fabrication to provide fixtures to meet your particular needs. (See attached questionnaire.)

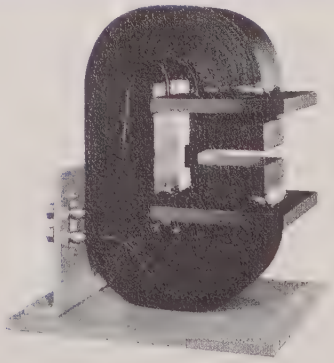
Special Coil Fixture



Special Multipole Fixture



Special Horizontal C-Core Fixture



Special Vertical C-Core Fixture

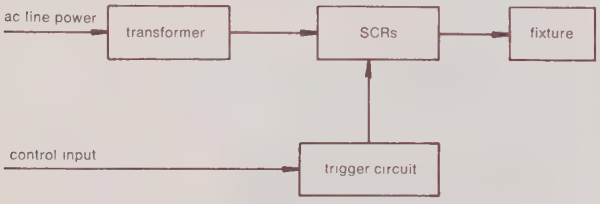
Rack Mount model HU-7049
stabilizer power unit

stabilizers

FUNCTIONAL DESCRIPTION

A step-down transformer reduces the ac line voltage to a level that is compatible with the fixture characteristics. The lower voltage is applied to a pair of back-to-back SCR's in series with the stabilizer output. The control input is converted to timed, line-synchronized pulses by the firing circuit.

Thus the control input adjusts the fixture current by controlling the conduction angles of the back-to-back SCR's. The control input may be manual (field control knob) or automatic (from a demagnetization or a stabilization controller).



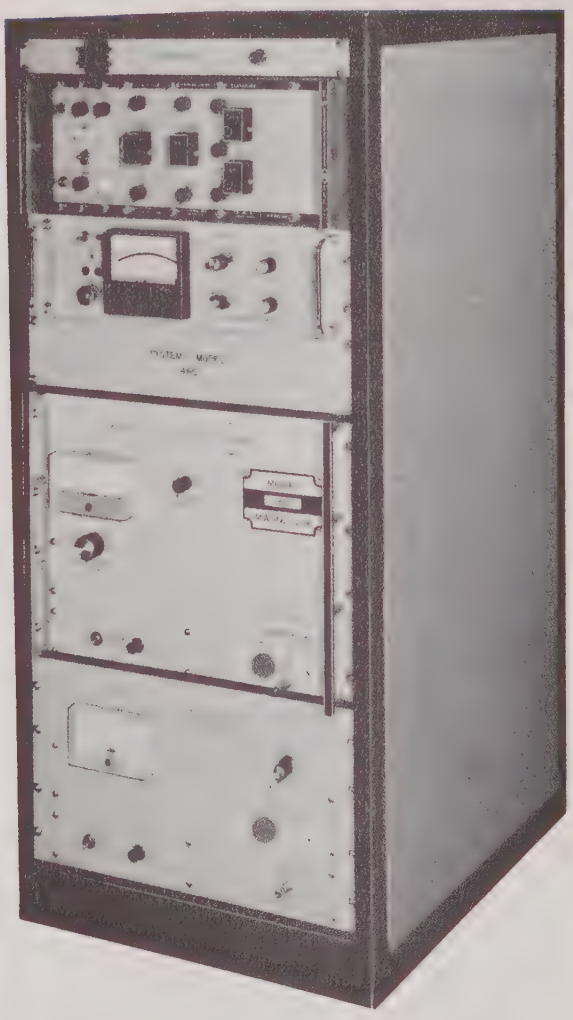
BLOCK DIAGRAM

stabilizer specifications

Model: HU-7049
Power: 117 V, 60 Hz, 30 A
Size: 19" w x 10.5" h x 17" d
(482.6 mm x 266.7 mm x 431.8 mm)
Weight: 100 lb. (45.45 kg)
Shipping weight: 150 lb. (68.20 kg)
Output:

Voltage, RMS at full power	Current, continuous
3 V	200 A
6 V	200 A
9 V	100 A
12 V	200 A
18 V	100 A
24 V	100 A

Higher currents are possible at reduced duty cycle



Model 460 Magnet Processing System

Designed to be used with a large variety of fixtures, standard or special, for the purpose of magnetizing and stabilizing magnets or magnet assemblies to a desired field density level. In addition to processing the magnet, the system checks for proper final value. Processing proceeds automatically in the sequence of magnetize, test for saturation, stabilize, and test for final value. If the saturation test indicates "Below" the cycle will terminate, skipping the regular stabilize sequence. Manual operation is also possible, permitting magnetizing and stabilizing to be initiated individually by panel buttons.

Subsidiary,
Magnetics & Electronics, Inc.

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

F.W. BELL

SALES BULLETIN

Subject: MAGNET PROCESSING EQUIPMENT PRICING **No.** 133

MAGNETIZERS IN BENCH CABINETS

Model 860 Magnet Charger	$1805.00
Model 860A Magnet Charger	1960.00
Model 861 Magnet Charger	2100.00
Model 861A Magnet Charger	2240.00
Model 870 Magnet Charger	2425.00
Model 870A Magnet Charger	2625.00
Model 871 Magnet Charger	2710.00
Model 871A Magnet Charger	2915.00
Model CS-6020 Magnet Charger	605.00

MAGNETIZERS IN RACK MOUNT CONFIGURATION

Model 8625 Magnet Charger	$1540.00
Model 8625A Magnet Charger	1690.00
Model 8626 Magnet Charger	1820.00
Model 8626A Magnet Charger	1955.00

CAPACITOR BANKS IN RACK MOUNT CONFIGURATION

Model 8635 Capacitor Bank, 30,000μF (12 Capacitor)	$ 790.00
Model 8635A Capacitor Bank, 20,000μF (8 Capacitor)	680.00
Model 8635B Capacitor Bank, 10,000μF (4 Capacitor)	560.00

STANDARD MAGNETIZING FIXTURES

Model C-601 Magnetizing Coil (for use with CS-6020 only)	$ 140.00
Model C-601A Magnetizing Coil	170.00
Model C-602 Magnetizing Coil	180.00
Model C-603 Magnetizing Coil	190.00
Model C-604 Magnetizing Coil	200.00

DEMAGNETIZER IN RACK MOUNT CONFIGURATION

Model HU-7049 Stabilizing Power Unit	$1330.00

REVISION 1 MARCH 1980

6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

Majestic Industries Inc
Teterboro, N. J.

CURRENT GUN™ PROBE

Model CG-100A

A truly portable clamp-around probe that lets you read *dc*, *ac* and *ac-on-dc* currents on your voltmeter, multimeter or scope. Measures 1 to 200 A; dc to 1.0 kHz, on conductors to ¾" diameter.

No need to break the circuit—no need to disturb the insulation—no exposure to dangerous bus or transient voltages—no inserted impedance. In a word: fast, easy, accurate and safe one-handed current measurements.

Here's how it works: a current generates a magnetic field around its conductor which is directly proportional to the magnitude and polarity of that current (Ampere's Law). The CG-100A accurately concentrates that field in a magnetic core surrounding its clamp-around jaws. A Hall-effect generator is mounted in an air-gap in the core. This small semiconductor device produces an output voltage directly proportional to the strength and direction of the magnetic field in the gap. Hence, the voltage output of the Hall generator is directly proportional to the current in the conductor.

The Hall generator output voltage feeds a dc-coupled linear operational amplifier. The amplified output is, therefore, a true voltage analog of the current waveform in the conductor. It may be viewed on an oscilloscope or read on a voltmeter as average, true rms (ac and dc) or peak, entirely determined by the type of meter used. Connection is made with a standard dual banana plug cable supplied with the probe.

A range switch selects one of two amplifier sensitivities, calibrated to give a rated output of ±1.0 V for ±10 A or ±1.0 V for ±100 A, at 2% accuracy. Both ranges have 100% overrange capability at reduced reading accuracy.

There are only two other electrical controls: a Press-to-Read switch with mechanical slide-lock, and a Zero Adjustment Thumbwheel to zero the probe for dc readings. A low-battery indicator illuminates before the reading accuracy of the probe is affected.

Currents under 1.0 A may be read with reasonable accuracy by looping a number of turns of the conductor through the jaws, thus effectively "multiplying" the current.

NEW AUGUST 1978 LITHO IN USA 64004

Model CG-100A

CURRENT GUN™ PROBE

APPLICATIONS

- Measure ground currents ac and dc.
- Measure power supply ripple.
- Measure current distribution in multiple mesh systems.
- Measure current balance (two wires) ac or dc.
- Measure telephone ringing currents.
- Measure current in audio distribution systems (using 440 Hz to 1000 Hz signals).
- Measure starting currents without introducing impedance (imparts negligible inductance in the μH range).
- Measure capacitor leakage.
- Measure transformer currents.
- Measure battery currents.
- Display current transients to limit of frequency response.
- Measure current distribution and perform ripple tests in plating operations.
- Read currents in HV conductors through nonmagnetic insulation.

SPECIFICATIONS

RANGES:	±10 A dc or 10 A ac ±100 A dc or 100 A ac
RATED OUTPUT:	±1 0 V at 10 A ±1.0 V at 100 A
ACCURACY:	±2.0% of Rated Output
OVERRANGE CAPABILITY:	100%. Error will not exceed ±3.0% of reading at 200 A dc or peak ac.
FREQUENCY RESPONSE:	dc to 1.0 kHz
RECOMMENDED LOAD:	≥3.0 kΩ
TEMPERATURE RANGE:	+15°C to +35°C — for specified accuracy −10°C to +50°C — storage and operation at reduced accuracy.
HEATING LIMITATION:	Prolonged operation above 200 A ac or 1 kHz can cause damage to the CG-100A.
WITHSTAND CAPABILITY:	Core to output — 600 V dc or 480 V ac. Case to output — rated at 2 kV.
APERTURE SIZE:	¾" (19mm) diameter
SIZE-OVERALL:	9" x 4½" x 1-7/16" (230mm x 115mm x 37mm)
WEIGHT:	14 ounces (0.4 kg), with batteries
POWER:	4 — "AA" cells.
BATTERY LIFE:	Alkaline — 30 hours continuous Mercury — 60 hours continuous

CAUTION: The CG-100A is not to be used on bare conductors or at circuit voltages above 600 V dc or 480 V ac.

Subsidiary,
Magnetics & Electronics, Inc.

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

SPECIFICATIONS SUBJECT TO CHANGE WITHOUT NOTICE

F.W. BELL INC.

DIGITAL CURRENT METER

MODEL 1776

DESCRIPTION

The F. W. Bell model 1776 Digital Current Meter provides a revolution in metrology with its ability to measure ac, dc, and ac on dc current with non-contact clamp-on probes. No longer is it necessary to break a circuit to make a measurement. This saves time and is extremely helpful in the trouble shooting, repair, and design fields. Now it is possible to obtain current measurements more quickly, easily, and safely than voltage measurements.

Taking current readings with the F. W. Bell model 1776 produces virtually no disturbance in the measured circuit. The clamp-on feature of the probe offers the advantages of complete isolation, no dc insertion loss, and negligible ac insertion loss. These qualities are especially valuable in making difficult transient response tests.

The internal calibration feature of the 1776 eliminates the requirement for an external reference current source. All 1776 probes can be calibrated with any digital current meter using this internal calibration feature.

The 1776 special circuitry, the clamp-on probes, and the 3½ digit readout provide a wide dynamic range of accurate measurements with excellent resolution. With the model P-102 probe, the 1776 can accurately measure up to 1000 amperes dc or ac peak, or with the P-100 probe, provide a resolution of 20 milliamperes. The 1776 is designed for portable operation with internal rechargeable batteries and for 115/230 V ac, 50/60 Hz line operation.

These unique capabilities make the 1776 Digital Current Meter the most versatile and usable current measuring instrument available.

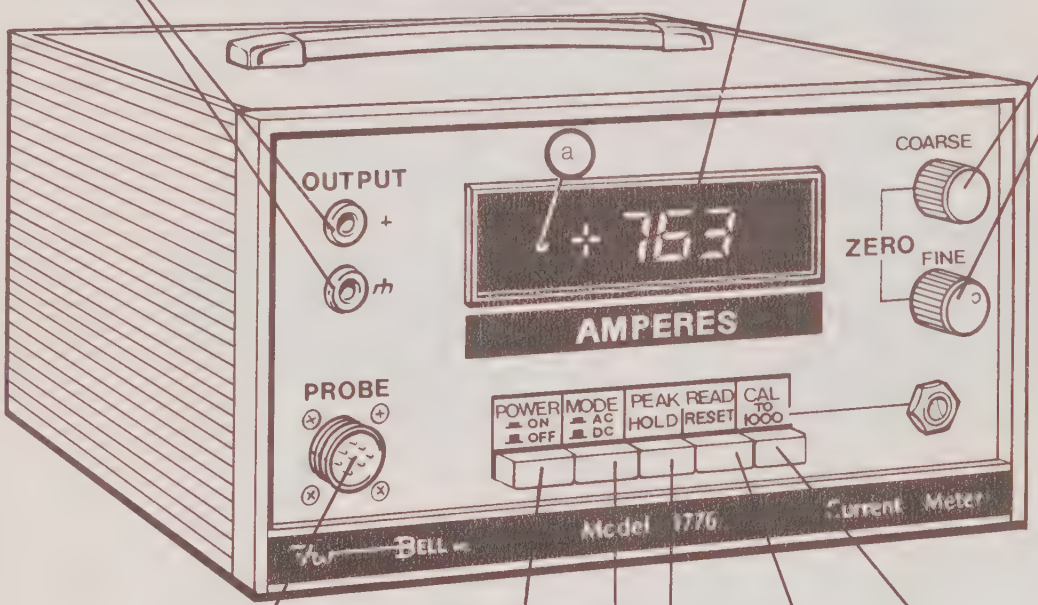
REVISION OCTOBER 1977 Printed in U.S.A. Number 60921

1776 CONTROLS AND SPECIAL FEATURES

OUTPUT
±1 volt for full scale indication on dc, 1 volt rms for full scale indication on ac.

DIGITAL READOUT
This 3½ digit display shows the current measured. Polarity of dc currents is also indicated.

ZERO
Coarse and *fine* zero controls, zero the instrument reading.



(a) BATTERY INDICATOR
This indicator lights when the internal battery charge level drops to a point where accurate measurements are no longer possible. The 1776 should be operated on the line or recharged for later use when this lights.

PROBE CONNECTOR
One of three available probes can be connected here. The instrument automatically ranges to the appropriate probe when it is connected.

ON/OFF SWITCH
Depress this button to turn the instrument on.

AC-DC FUNCTION
When depressed, this switch permits ac current measurements. When released, the instrument is in dc mode.

PEAK READ
When the HOLD button is depressed, the 1776 will read and hold the highest positive peak current indefinitely until the RESET button is used to clear the instrument.

RESET
This button clears the peak reading indication and prepares the instrument for the next peak reading.

CALIBRATE
Depress this button to calibrate the 1776 to a full scale reading of 1000.

INSTRUMENT FEATURES

DIGITAL READOUT

A 3½ digit readout provides a direct indication of the dc, ac, ac on dc, or peak current being measured. For ac current the meter is average responding calibrated to indicate the rms value of a sine wave function. For dc current the polarity is also indicated.

ANALOG OUTPUT

A ±1 V full scale analog output is available for all modes of current measurement. For the dc and Peak Read and Hold modes it is ±1 V dc; in the ac mode, the 1 V rms analog output will follow the wave shape of the current being measured

PEAK READ AND HOLD

This feature permits the 1776 to read and hold the highest positive peak of a varying or transient current.

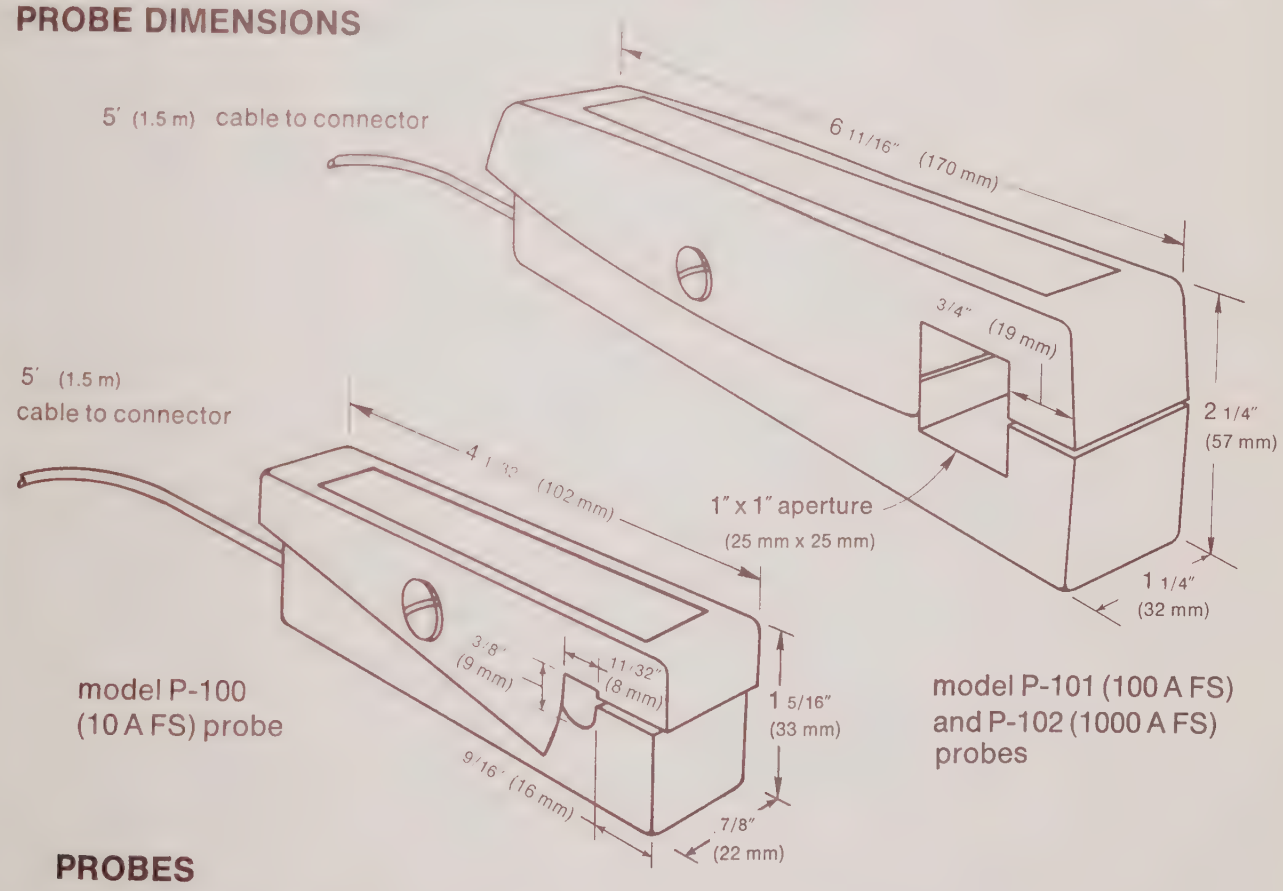
PORTABLE

Internal, rechargeable batteries permit completely portable operation. They are on full or trickle charge when the instrument is plugged into a suitable ac source.

RESOLUTION

Resolution of the 1776 with the P-100 probe is ±20 mA. The P-101 probe gives a ±0.2 A resolution and the P-102 probe yields a ±2 A resolution.

PROBE DIMENSIONS


5' (1.5 m) cable to connector
6 11/16" (170 mm)
3/4" (19 mm)
2 1/4" (57 mm)
1" x 1" aperture (25 mm x 25 mm)
1 1/4" (32 mm)
5' (1.5 m) cable to connector
4 1/32" (102 mm)
3/8" (9 mm)
11/32" (8 mm)
1 5/16" (33 mm)
9/16" (16 mm)
7/8" (22 mm)
model P-100 (10 A FS) probe
model P-101 (100 A FS) and P-102 (1000 A FS) probes

PROBES

There are three standard non-contact, clamp-on probes available for use with the 1776 Digital Current Meter. Each hand held probe is designed for a different full scale current range. These ranges are 10 amperes full scale for the P-100 probe, 100 amperes for the P-101 probe, and 1000 amperes for the P-102 probe. The instrument range is automatically set by the probe connection. All three probes can be calibrated using the internal calibration feature of any 1776 Digital Current Meter. The P-100 and P-101 probes have a 100% overrange capability with slightly reduced accuracy.

For accurate readings, the probe must close completely around the conductor. This is done easily since the probes are designed for one hand operation.

MODEL 1776 DIGITAL CURRENT METER

SPECIFICATIONS

current ranges, dc and ac rms	0 to 10.00 A FS with probe P-100; overrange to 19.99 A 0 to 100.0 A FS with probe P-101; overrange to 199.9 A 0 to 1000 A FS with probe P-102; no overrange.
overall accuracy, including probes	
dc and sinusoidal ac to 1000 Hz	normal range: ±1.0% FS at 25°C overrange: ±2.5% FS at 25°C.
peak reading	±2.0% FS.
frequency response in ac mode	10 Hz to 5000 Hz.
additional error 1000 Hz to 5000 Hz	with P-100 (10 A) probe: +2.0% of reading, typical. with P-101 (100 A) probe: +3.0% of reading, typical. with P-102 (1000 A) probe: +3.0% of reading, typical.
peak reading	frequency response : 1000 Hz fastest readable rise time: 250μs to full scale.
output voltage	in dc mode: ±1.0 V for full scale indication. in ac mode: 1.0 V rms for full scale indication of sinusoidal current. in peak hold mode: +1.0 V hold for full scale peak hold indication.
readout	digital, 3½ digits.
probe isolation capability	600 V dc or ac peak.
power requirements	115/230 V ac, 50/60 Hz and internal rechargeable Nicad batteries with built-in trickle charge circuitry (voltage selection is made at the factory) 15 W.
size	5½″ high, 10″ wide, 10″ deep (140 mm x 254 mm x 254 mm).
weight	net 10 lbs. (4.5 kg), shipping 13 lbs. (5.9 kg).
operating temperature range	–10°C to +50°C.
special features	All probes can be calibrated using the internal calibration feature of any 1776. The P-100 (10A) and P-101 (100A) probes have 100% overrange capability with slightly reduced accuracy.

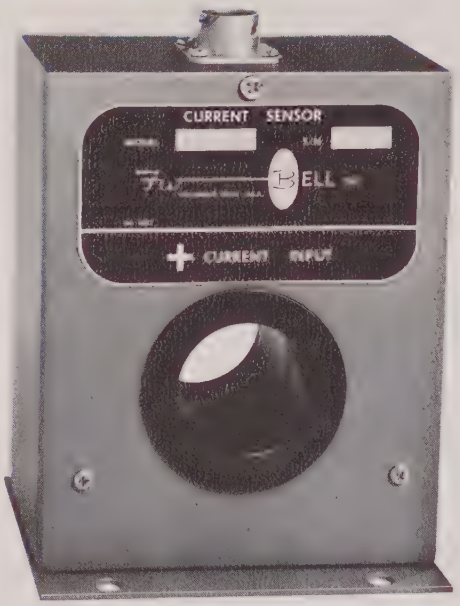
Specification subject to change without notice.

Subsidiary,
Magnetics & Electronics, Inc.

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

NON-CONTACT DC CURRENT SENSORS

IA-5020P SERIES



FEATURES

- Complete isolation
- Zero dc insertion loss
- Linearity 0.5% RO
- Fast Response
- High Level Output
- Bi-directional
- Temperature compensated
- Magnetically shielded

DESCRIPTION

Current sensors of the IA-5020P Series are fast responding devices for measurement of dc current up to 2000 A. When excited with ±15V dc, the sensors will provide an output voltage that is accurately proportional to the measured current and identical in waveform. The output polarity is indicative of the direction of current flow.

Each sensor consists of a gapped toroidal core, a Hall generator, an output amplifier and compensating circuitry. These components are epoxy potted into a magnetically shielding steel case. This case contains a 1½" diameter measurement aperture, the five pin connector and the mounting flange.

The Hall generator is a four pole magneto-sensitive device mounted in the core gap. The magnetic field in the gap is proportional to the unknown current flowing through the aperture. The Hall generator produces an output voltage proportional to this magnetic field and thus proportional to the aperture current.

This Hall generator output is amplified to the range of 0 to 10 volts. Therefore, an accurate measure of the unknown current is provided without making direct contact to the measured circuit.

APPLICATION

Since the sensor is only magnetically coupled with the current carrying conductor, it offers the advantage of no dc insertion loss. Problems associated with shunts (no isolation, power loss and heating effects) are totally eliminated.

Typical applications are: current sensing on dc motors in drilling rigs and machine tools, on traction motors, in electric ovens, on dc circuit breakers, on battery powered vehicles and on high dc current power supplies.

The excitation must be derived from a ±15 V dc source, capable of supplying 50 mA dc. Regulating circuit elements reduce the influence of supply voltage fluctuations.

The magnetically shielding steel case greatly reduces the effects on the accuracy caused by currents in adjacent conductors and by ferrous metals in close proximity to the sensor; it permits mounting of the sensor directly on a steel bulkhead or on a steel mounting bracket without jeopardizing accuracy or calibration.

The sensor is designed to measure dc current with a ripple content up to 200A rms. Higher ripple contents will cause excessive heat dissipation. The output polarity is related to the direction of current flow thru the aperture; it reverses when the current flows in the opposite direction.

REVISED NOVEMBER 1978 LITHO IN U.S.A. NUMBER 60816

IA-5020P SERIES

NON-CONTACT DC CURRENT SENSORS

SPECIFICATIONS

Measuring Circuit

Rated Current	See Table
Frequency	dc
Permissible Ripple content	<200A rms at 360 Hz. max.

Excitation Circuit

Voltage	±15 V dc at 50 mA dc

Output Circuit

Rated Output (RO)	±10 V dc
Linearity	<±0.5% RO
Repeatability	<±0.5% RO
Response time to 99%	<150 μs
Output load resistance	≥2 kΩ

Influences on the Accuracy

Temperature, ambient −30°C to 75°C	≤1%
Zero Offset (Hysteresis)	<0.5% RO
Power Supply variation ±1 V	<0.2%
Eccentric position of small conductor in the aperture	<0.3%
Close proximity of return conductor	<0.2%
Close proximity of ferrous metals	<0.2%

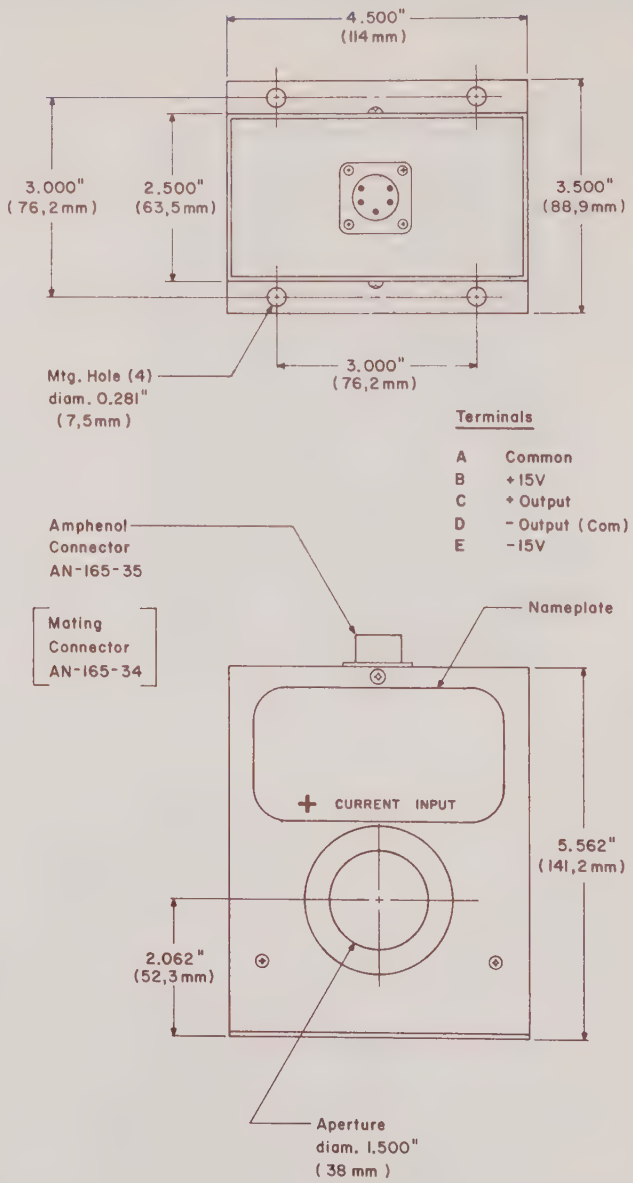
Withstand Capabilities

Dielectric test between a bare 1½" conductor thru the aperture and the sensor circuits, case and connector	6 kV rms
Measured current overload	no damage
Output short or open circuit	no damage

CALIBRATION

The transducer is factory calibrated to an output voltage of +8 V dc across 10 kΩ with a dc current flowing into the aperture side marked +, raised from zero to 80% of rated current. The calibration is performed in an ambient of 25°C ±1°C.

OUTLINE



Case : Steel Weight : 5 lb, 10 oz (2,6 kg)

Aperture : Thermo-Plastic Collar

TABLE OF MODELS

Model number:	IA-5020P	IA-5021P	IA-5022P	IA-5023P
Rated current:	±2000 A dc	±1000 A dc	±500 A dc	±250 A dc
	IA-5024P ±3000 A dc LIN. −0.6% RO			

specifications subject to change without notice

Printed in U.S.A.

Subsidiary, Magnetics & Electronics, Inc.

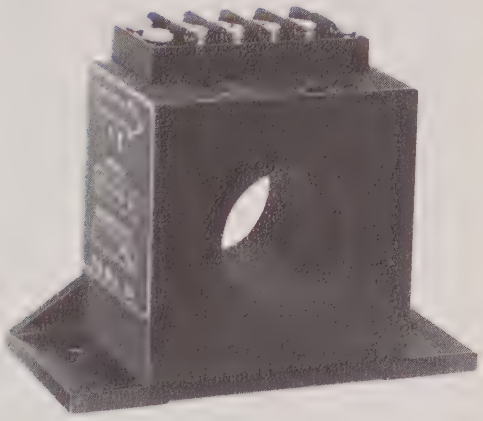
BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

NON-CONTACT DC & AC CURRENT SENSORS

ID-5000M SERIES

FEATURES

- Complete isolation
- Zero dc insertion loss
- Linearity 2% FS
- Fast response
- Bi-directional
- Small size, light weight
- Low cost



DESCRIPTION

ID-5000M Series current sensors are small, light weight, inexpensive devices for non-contact current measurement up to 350 A dc or peak ac, in the frequency range from dc to 1 kHz. Each sensor consists of a gapped toroidal core, a Hall generator located in the core gap and associated circuitry. The components are epoxy potted in a thermo-plastic case. The case has two mounting flanges, an aperture for the current conductor, and screw terminals for the excitation and output circuits. Four #2 spring spade lugs are supplied with each unit.

Each sensor requires excitation as detailed in the Table of Specifications. This excitation must be derived from a suitable external source. When properly excited the ID-5000M sensors will provide an isolated output voltage directly proportional to the current passing through the aperture. The waveform of this output voltage is identical to the waveform of the measured current when the sensor operates with dc excitation. The principle of operation is described in detail in the section Measurement Theory.

The only coupling between the sensor and the current carrying conductor is magnetic. This offers the advantages of complete isolation, no dc insertion loss, and a negligible ac insertion loss. The common problems associated with shunts (no isolation, power dissipation, and heating effects) are totally eliminated.

TYPICAL APPLICATIONS

- Monitoring and control of dc motor circuits
- Overload sensor in dc power supplies
- Control of dc motor driven machine tools
- Replacements for shunts, particularly in hostile environments, in airborne circuits and when isolation is required
- Monitoring and control of battery load and charge circuits
- Current sensing element in feedback circuits, on interlocks and on dc circuit breakers
- Process control element in dc operated processes
- Power measurement in dc power circuits

REVISED APRIL 1980 Printed in USA NUMBER 60817

USING THE ID-5000M SERIES SENSORS

General

The series consists of four models that differ in excitation requirements and output characteristics as shown in the Table of Specifications. Select the model that best fits the intended application. To perform current measurement simply pass the current carrying conductor through the aperture and apply the specified excitation to the excitation terminals (labeled ± Ic or ± 15 V). An output voltage accurately proportional to the measured current will then appear at the output terminals (labeled ± OUT).

Excitation Supply

The model ID-5001M is designed to operate with an excitation *current* derived from a regulated current source that can supply 40 mA dc at up to 5 V. Model ID-5011M requires *voltage* excitation derived from a regulated voltage source that can supply 15 V dc at up to 40 mA. Both the ID-5001M and ID-5011M may be operated with excitation at lower than the rated levels. In this case their sensitivities will be proportionally lower. Both models can also operate with ac excitation. In this mode of operation, the waveform of the output voltage will be the product of the waveforms of the excitation and of the measured current.

Example: when using 60 Hz excitation and measuring dc current, the output voltage will be a 60 Hz signal with an amplitude proportional to the measured current.

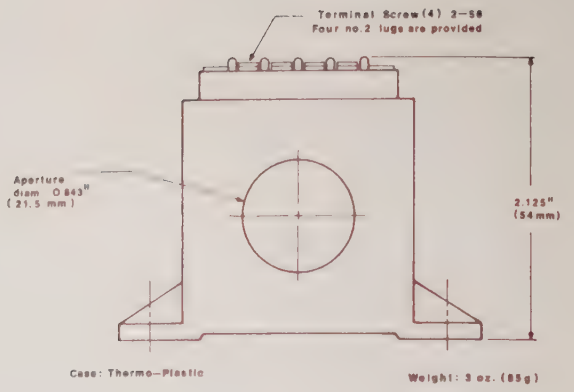
CAUTION: ***Excitation at more than 10% above the rated levels may cause damage to the ID-5001M and ID-5011M.***

Models ID-5021M and ID-5031M are designed for *dc voltage excitation only*. The supply requirement is 15 V dc at up to 45 mA. Since these models feature a built-in excitation regulator, they are less susceptible to fluctuations of the excitation voltage.

CAUTION: ***Applying excitation voltage with the wrong polarity to models ID-5021M and ID-5031M will cause damage to the sensors.***

Polarity

The output polarity is related to the polarity of the excitation and the direction of the measured current flow, through the aperture, as shown on the sensor's label. Upon reversal of the current flow, the output polarity will reverse.



Grounding

The excitation circuit and the output circuit are interconnected in the Hall generator (see schematic diagram). A common connection of these two circuits *outside* the sensor will short-circuit the Hall generator, adversely affecting the sensor operation. ***Either the excitation circuit or the output circuit may be grounded, but not both.*** When feeding two or more sensors from a common excitation supply, the output circuits must be kept isolated from each other.

Zero Current Offset

At zero measured current, an offset voltage appears at the output terminals. The offset voltage of the model ID-5001M can be substantially reduced by adjusting an external nulling circuit as shown in the schematic diagram. The other three models feature internal offset compensation.

Sensitivity

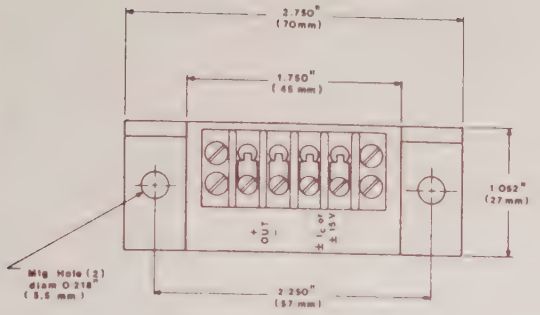
The sensitivity of the model ID-5001M varies from unit to unit, but is not less than 0.5 mV/A nor more than 1.1m V/A at rated excitation. The sensitivity of each model ID-5001M is determined at the factory and stamped on its nameplate label.

The sensitivity of the ID-5011M, ID-5021M and ID-5031M models is factory calibrated to 0.5 mV/A at rated excitation. These models are recommended for applications that require a constant sensitivity from unit to unit.

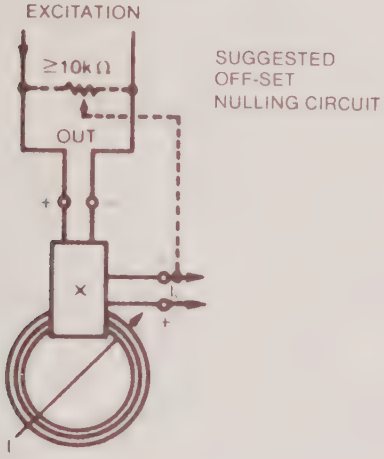
Increased Sensitivity

Lower current levels can be measured with increased sensitivity by looping the current carrying conductor a number of turns through the aperture. When the number of turns is N, the current range is reduced by a factor 1/N and the sensitivity is increased by a factor N. For example, ten (10) turns through the aperture will change the current range from 0-350 A to 0-35 A and increase the sensitivity ten-fold.

OUTLINE



SCHEMATIC



Calibration

To achieve optimum linearity over the full operating range, factory calibration is performed at a level that is lower than the rated maximum current. The calibration level of each model is shown in the Table of Specifications. The calibration is performed with an output load of 10 k Ω.

Current Overload

Current overloads (either continuous or transients) will not damage the sensors. At current levels above 350 A, the sensor sensitivity has a roll-off characteristic. Typically, at 500 A the output error may amount to —10% FS.

Frequency

The upper frequency limit for accurate current measurement is 1 kHz. The sensors will measure current at higher frequencies with reduced accuracy. However, continuous operation with currents at frequencies higher than 1 kHz may cause damage to the sensors. Consult the factory about applications that involve current measurement at higher frequencies.

Power Measurement

The model ID-5001M can be used to measure dc power. For details, refer to Application Bulletin No. 100-I, available from F. W. Bell, Inc.

ADVANTAGES OF HALL-EFFECT CURRENT MEASUREMENT

Hall-effect current sensing is a unique method of measuring electric current which offers many advantages. Some of these are non-contact operation, high degree of accuracy, dc and ac current measurement, ability to indicate direction of current flow, and low circuit loading.

Unlike a shunt, an ID-5000M Series sensor offers complete isolation, does not pose any power dissipation problems, and does not introduce a series load in the measured circuit. Unlike current transformers, which are limited to ac current measurement in a narrow frequency range, the ID-5000M Series sensors measure dc as well as ac currents in a wide frequency range.

Other current measuring devices such as clamp-on ammeters, usually have a low accuracy, a very limited frequency response, provide no output signal, and are highly susceptible to influences caused by external magnetic fields and eccentric positioning of the conductor. The Hall-effect principle, as applied in the ID-5000M Series sensors, not only provides an accurate output signal and operates over a wide frequency but also makes the devices relatively independent of external magnetic fields and eccentric positioning of the conductor within the aperture.

MEASUREMENT THEORY

The ID-5000M Series current sensors operate on the principle of Ampere's Law which states that current in a conductor produces a proportional magnetic field surrounding the conductor. The ID-5000M Series sensors measure current accurately by sensing the strength of the generated magnetic field.

Each sensor contains a Hall generator mounted in a gapped toroidal core. The current carrying conductor is passed through the core aperture. The core concentrates the magnetic field and passes it through the Hall generator.

The Hall generator is a magneto-sensitive semi-conductor that provides an output voltage proportional to the product of the magnetic field normal to its surface and the control current flowing through it. The control current is derived from the excitation supply. Since the control current is held constant the output voltage is proportional to the generated magnetic field. According to Ampere's Law this is also proportional to the current in the aperture.

TABLE OF SPECIFICATIONS

Model:	ID-5001M	ID-5011M	ID-5021M	ID-5031M
Measuring Circuit				
Current range, dc or ac peak	0 to 350 A	0 to 350 A	0 to 350 A	0 to 350 A
Frequency range	dc to 1 kHz	dc to 1 kHz	dc to 1 kHz	dc to 1 kHz
Inductance (1 turn)	0.1 μH	0.1 μH	0.1 μH	0.1 μH
Calibration level	325 A	275 A	325 A	325 A
Excitation Circuit				
Rated excitation	40 mA dc or ac rms at ⩽5 V	15 V dc or ac rms at ⩽40 mA	15 V dc at ⩽45 mA	15 V dc at ⩽45 mA
Input resistance	40 to 120 Ω	⩾375 Ω	⩾300 Ω	⩾300 Ω
Output Circuit				
Sensitivity, minimum nominal maximum	0.5 mV/A — 1.1 mV/A	— 0.5 mV/A —	— 0.5 mV/A —	— 0.5 mV/A —
Calibration tolerance	±0.5 %	±2.5 %	±0.5 %	±0.5 %
Linearity, 0 to 350 A Error at 500 A	±2 % FS <−10 %	±2 % FS <−10 %	±2 % FS <−10 %	±2 % FS <−10 %
Response time to 99%	50 μs	50 μs	50 μs	50 μs
Source resistance	70 to 300 Ω	70 to 300 Ω	70 to 300 Ω	70 to 300 Ω
Load resistance	⩾10 kΩ	⩾10 kΩ	⩾10 kΩ	⩾10 kΩ
Influences on the Accuracy				
Zero current offset	<±16 mV	<±1 mV	⩽±1 mV	⩽±0.1 mV
Excitation variation ±1%	±1 %	±1 %	<±0.1 %	<±0.1 %
Temperature, ambient −40°C to 80°C	<−0.1 %/°C	<−0.1 %/°C	<−0.05 %/°C	<−0.05 %/°C
Close proximity of the return conductor	<0.25 %	<0.25 %	<0.25 %	<0.25 %
Close proximity of ferrous metals	<0.15 %	<0.15 %	<0.15 %	<0.15 %
Eccentric position of conductor in the aperture	<0.05 %	<0.05 %	<0.05 %	<0.05 %
Withstand Capabilities				
Dielectric test between a bare ¾″ diameter conductor thru the aperture and the sensor circuits	6 kV rms	6 kV rms	6 kV rms	6 kV rms
Output short or open circuit	no damage	no damage	no damage	no damage

Consult the factory about the availability of special models with other measured current ranges, different excitation voltages or other characteristics.

Specifications subject to change without notice.

Subsidiary,
Magnetics & Electronics, Inc

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

F.W. BELL

PRODUCT BULLETIN

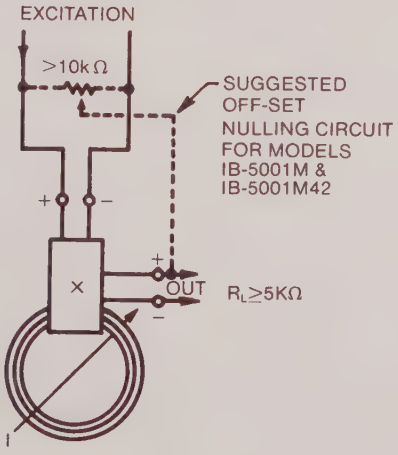
Subject: **ID-5001M-42 Series**
Non-Contact Current Sensors

No. 112

This series is identical to the ID-5001M series, described in the data sheet no. 60817. The specifications are identical to those of the ID-5001M series with the following exceptions:

	ID-5001M-42	ID-5011M-42
Current range dc or ac peak	0 to ± 100A	0 to ± 100A
Frequency range	dc to 1k Hz	dc to 1k Hz
Rated excitation		
dc or ac RmS	40mA	15V
Input resistance	80 ± 40 Ω	≥ 375 Ω
Output sensitivity	± 0.5mV/A ± 1.1mV/A	± 0.5mV

SCHEMATIC



Caution: Do not tie excitation circuit and output circuit to a common ground.

ATTACH DATA SHEET 60817

60817B

6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

NON-CONTACT DC & AC CURRENT SENSORS

IF-5000M SERIES

FEATURES

- Complete isolation
- Zero dc insertion loss
- Linearity 0.5% RO
- Fast response
- Bi-directional
- Low cost

DESCRIPTION

IF-5000M Series current sensors are fast responding devices for non-contact current measurement up to 3000 A dc or peak ac in the frequency range from dc to 1 kHz. They are similar to the ID-5000M Series sensors but have larger dimensions, accommodating conductors with an OD up to 1⅝".

Each sensor consists of a gapped toroidal core, a Hall generator located in the core gap and associated circuitry. The components are housed in a thermoplastic case with four thru mounting holes, a window for the current conductor and a barrier block with four #8 terminal screws for the excitation and output circuits.

Each sensor requires constant dc or ac current excitation to provide an isolated output voltage proportional to the current passing thru the window. The waveform of this output voltage is identical to the waveform of the measured current when the sensor operates with constant dc current excitation.

Constant current excitation for the 5000 models may be derived from a regulated 15 V dc supply thru a series resistor of a value that limits the current to 40 mA or less.

The only coupling between the sensor and the current-carrying conductor is magnetic. This offers the advantages of complete isolation, no dc insertion loss and a negligible ac insertion loss. The common problems associated with shunts (no isolation, power dissipation and heating effects) are totally eliminated.

TYPICAL APPLICATIONS

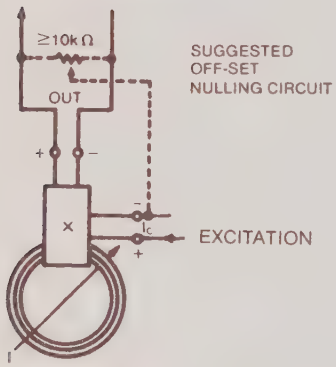
- Monitoring and control of dc motor circuits
- Overload sensor in dc power supplies
- Control of dc motor driven machine tools
- Replacements for shunts, particularly in hostile environments, in airborne circuits and when isolation is required
- Monitoring and control of battery load and charge circuits
- Current-sensing element in feedback circuits, on interlocks and on dc circuit breakers
- Process control element in dc operated processes
- Power measurement in dc power circuits

Revised September 1980 Litho in U.S.A. Number 60815

TABLE OF MODELS[1]

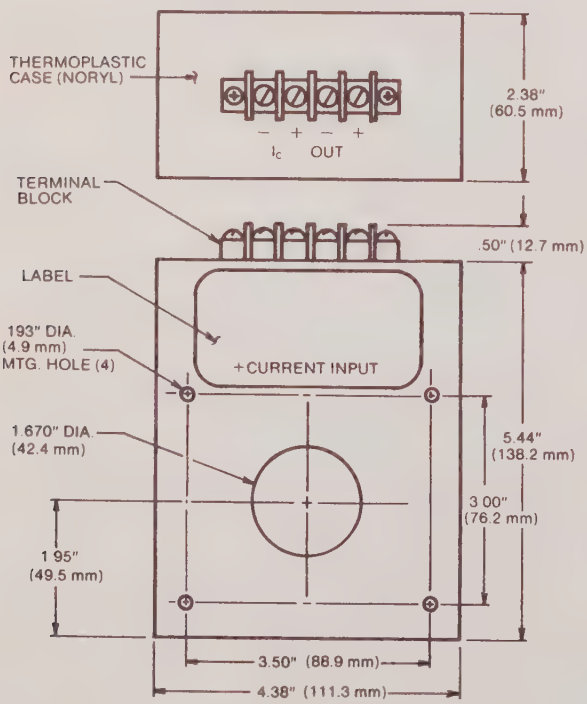
Model:	IF-5000M	IF-5001M	IF-5002M	IF-5003M	IF-5004M*
Current range, dc or ac peak	0 to ±2.0 kA	0 to ±1.0 kA	0 to ±0.5 kA	0 to ±0.250 kA	0 to ±3.0 kA
Frequency range	dc to 1 kHz	dc to 1 kHz	dc to 1 kHz	dc to 1 kHz	dc to 1 kHz
Output sensitivity, minimum	±0.05 mV/A	±0.15 mV/A	±0.15 mV/A	±0.300 mV/A	±0.05 mV/A
maximum	±0.10 mV/A	±0.30 mV/A	±0.30 mV/A	±0.600 mV/A	±0.10 mV/A

SCHEMATIC



Caution: Do not tie excitation circuit and output circuit to a common ground.

OUTLINE



Weight: 3 lb, 6 oz. (1.5 kg)

Specification subject to change without notice.

COMMON SPECIFICATIONS

Excitation Circuit[2]

Rated excitation	40 mA dc or ac rms
Input resistance	80 ± 40 Ω

Output Circuit[2]

Calibrated sensitivity with rated excitation	See label
Linearity	±0.5% RO
	*±0.6% RO
Response time to 99%	<50 μs
Source resistance	210 ± 150 Ω
Load resistance	≥ 10 kΩ

Influences on the Accuracy

Zero current offset[3]	≤± 16 mV
Excitation variation ±1%	±1 %
Temperature, ambient −40°C to 80°C	<−0.1 %/°C
Close proximity of the return conductor	<0.5 %
Close proximity of ferrous metals	<0.2 %
Eccentric position of the conductor in the window	<0.3 %

Withstand Capabilities

Dielectric test between a bare 1⅝" diameter conductor thru the window and the sensor circuits	6 kV rms
Output short or open circuit	no damage

Notes

1. Consult the factory about the availability of special models with modified features.
2. These two circuits are interconnected in the Hall generator; only one of them can be grounded.
3. This offset can be substantially reduced by adjustment of the suggested nulling circuit.

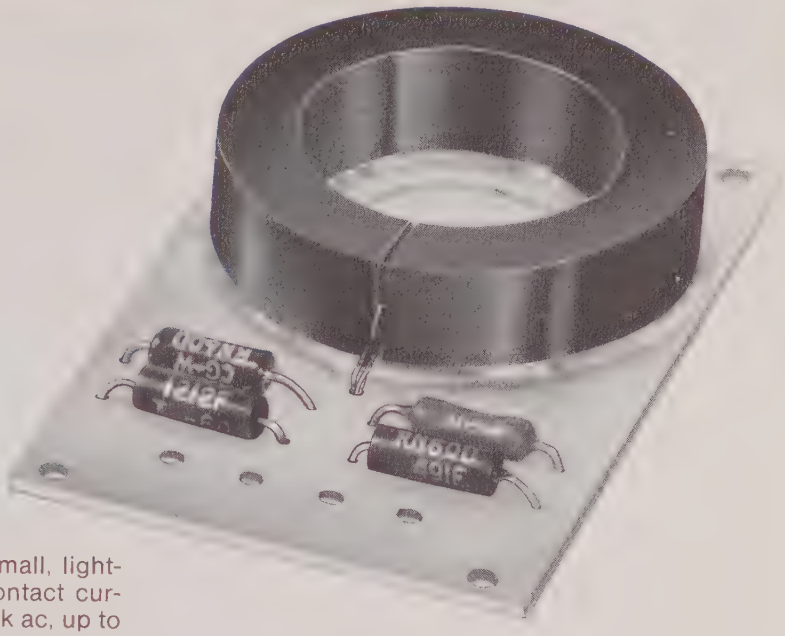
Subsidiary,
Magnetics & Electronics, Inc

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

F.W. BELL INC.

NON-CONTACT DC & AC CURRENT SENSORS

IB-5000M SERIES



FEATURES

- Complete isolation
- Zero dc insertion loss
- Linearity 2% RO
- Fast response
- Bi-directional
- Small size, lightweight
- Very low cost

DESCRIPTION

IB-5000M Series current sensors are small, lightweight, inexpensive devices for non-contact current measurement up to 350 A dc or peak ac, up to 1 kHz. They are similar to the ID-5000M Series sensors but feature an open, pc board construction, suitable for applications that do not require a protective housing and screw terminals.

Each sensor consists of a gapped toroidal core, a Hall generator located in the gap, and associated circuitry. The components are mounted on a pc board that has four mounting holes, a window for the current conductor and four solder terminals for the excitation and output circuits.

Each sensor requires constant dc or ac excitation as specified in the Table of Models to provide an isolated output voltage proportional to the current passing thru the window. The waveform of this output voltage is identical to the waveform of the measured current when the sensor operates with constant dc excitation.

Constant current excitation for the 5001 models may be derived from a regulated 15 V dc supply thru a series resistor of a value that limits the current to 40 mA or less. The 5011 models can be driven directly from a regulated 15 V dc source. All models will operate at lower-than-rated excitation with proportionally lower output sensitivity.

The only coupling between the sensor and the current-carrying conductor is magnetic. This offers the advantages of complete isolation, no dc insertion loss and a negligible ac insertion loss. The common problems associated with shunts (no isolation, power dissipation and heating effects) are totally eliminated.

TYPICAL APPLICATIONS

- Monitoring and control of dc motor circuits
- Overload sensor in dc power supplies
- Control of dc motor driven machine tools
- Replacements for shunts, particularly in hostile environments, in airborne circuits and when isolation is required
- Monitoring and control of battery load and charge circuits
- Current-sensing element in feedback circuits, on interlocks and on dc circuit breakers
- Process control element in dc operated processes
- Power measurement in dc power circuits

REVISED APRIL 1980 Litho in U.S.A. NUMBER 60814

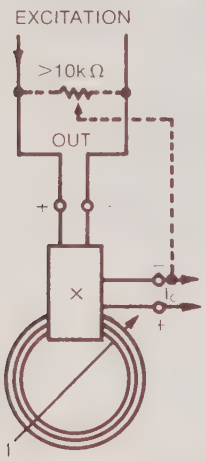
IB-5000M SERIES

NON-CONTACT DC & AC CURRENT SENSORS

TABLE OF MODELS[1]

Model:	IB-5001M	IB-5011M	IB-5001M42	IB-5011M42
Current range, dc or ac peak	0 to ±350 A	0 to ±350 A	0 to ±100 A	0 to ±100 A
Frequency range	dc to 1 kHz	dc to 1 kHz	dc to 1 kHz	dc to 1 kHz
Rated excitation, dc or ac rms	40 mA	15 V	40 mA	15 V
Input resistance, excitation circuit	80 ± 40 Ω	≥375 Ω	80 ± 40 Ω	≥375 Ω
Output sensitivity, minimum	±0.5 mV/A	—	±0.5 mV/A	—
nominal	—	±0.5 mV/A	—	±0.5 mV/A
maximum	±1.1 mV/A	—	±1.1 mV/A	—

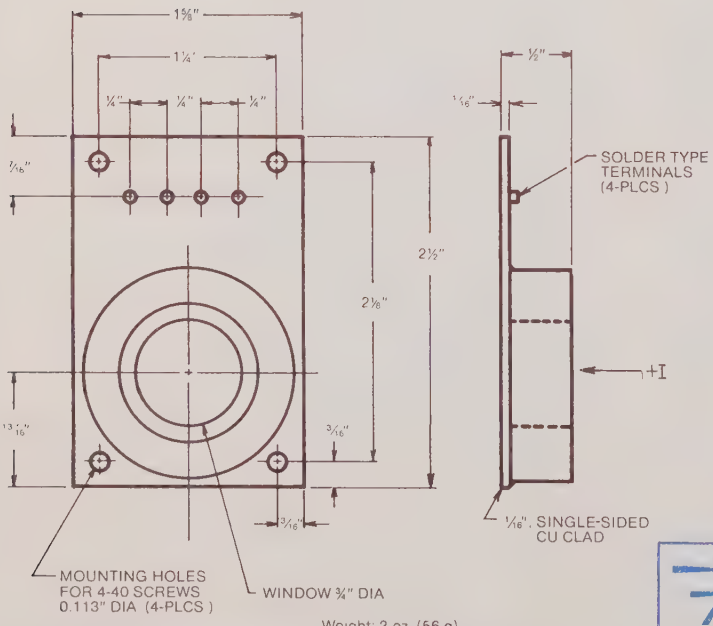
SCHEMATIC



SUGGESTED OFF-SET NULLING CIRCUIT FOR MODELS IB-5001M & IB-5001M42

Caution: Do not tie excitation circuit and output circuit to a common ground.

OUTLINE



Weight: 2 oz. (56 g)

Specification subject to change without notice.

COMMON SPECIFICATIONS

Output Circuit[2]

Calibrated sensitivity with rated excitation	See label
Linearity	±2 % RO
Response time to 99%	<50 μs
Source resistance	210 ± 150 Ω
Load resistance	≥10 kΩ

Influences on the Accuracy

Zero current offset[3]	≤±1 mV
Excitation variation ±1%	±1 %
Temperature, ambient −40°C to 80°C	<−0.1 %/°C
Close proximity of the return conductor	<0.5 %
Close proximity of ferrous metals	<0.2 %
Eccentric position of the conductor in the window	<0.1 %

Withstand Capabilities

Dielectric test between a bare ¾" diameter conductor thru the window, and the sensor circuits	1500 V rms
Output short or open circuit	no damage

Notes

1. Consult the factory about the availability of special models with modified features.
2. Output and excitation circuits are interconnected in the Hall generator; only one of them can be grounded.
3. Offset of the 5001 models are ≤±16 mV; it can be reduced to the specified level by adjustment of the suggested nulling circuit. The 5011 models feature a fixed, built-in nulling circuit.

Subsidiary, Magnetics & Electronics, Inc.

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

CURRENT MEASURING EQUIPMENT PRICE LIST

CURRENT METER & PROBES

dc & ac	
1776 Digital Current Meter	$890
P-100 (10 A) Probe	121
P-101 (100 A) Probe	121
P-102 (1000 A) Probe	121

NON-CONTACT PROBE

dc & ac	
CG-100A "CURRENT GUN" Probe	$189

FIXED CURRENT SENSORS

dc only	
IA-5020P	$347
IA-5021P	347
IA-5022P	347
IA-5023P	347
dc & ac	
IB-5001M	$ 36
IB-5001M42	36
IB-5011M	46
IB-5011M42	46
dc & ac	
ID-5001M	$ 49
ID-5011M	68
ID-5021M	79
ID-5031M	88
dc & ac	
IF-5000M	$ 86
IF-5001M	86
IF-5002M	86
dc & ac	
IF-5020P	$333
IF-5021P	333
IF-5022P	333
IF-5023P	333

Prices are per unit in quantities 1-9, fob Orlando, FL, not including applicable taxes. Terms are net 30 days.

Consult the factory for quantity discounts. Prices are subject to change without notice.

Subsidiary,
Magnetics & Electronics, Inc

BELL INC.
6120 Hanging Moss Road
Orlando, Florida 32807
Phone: 305-678-6900
TWX: 810-853-3115

Majestic Industries Inc.
Teterboro, N J.

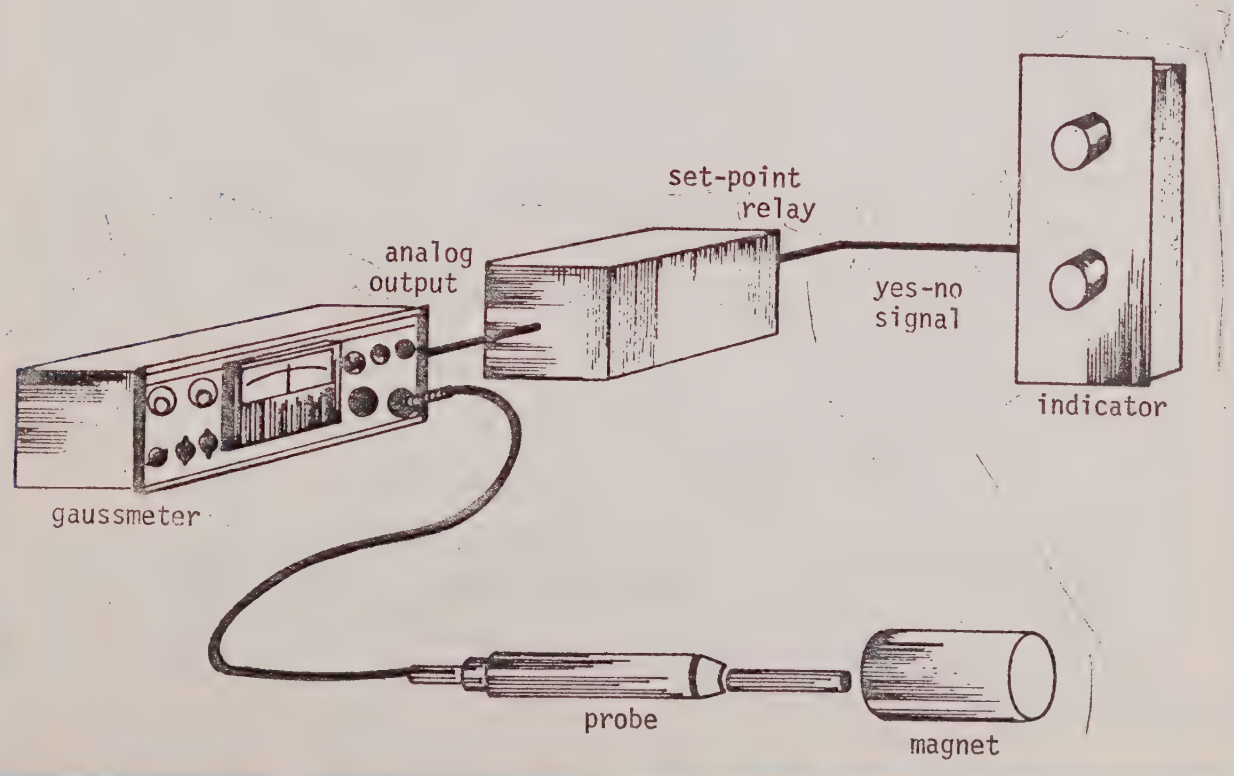
F.W. BELL

APPLICATION BULLETIN

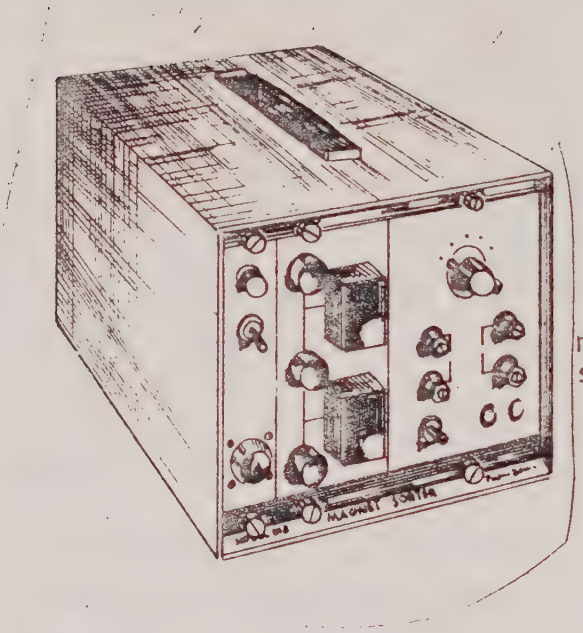
Subject: MAGNETIC TESTING AND SORTING **No.** 100G

Bell gaussmeters are commonly used to test and sort magnets in quality control and manufacturing applications. The speed of these operations may be increased markedly by supplimenting the meter readout with an audio alarm or a simple yes-no visual indicator.

This can be achieved by connecting a set point control relay to the gaussmeter analog output, 0 to 1 V dc. Connect the audio or visual alarm to the relay output, (bell, buzzer, lightbulb, etc.). Adjust the system with a test magnetic field. Observe the gaussmeter reading and adjust the relay to actuate at the desired field level.



6120 Hanging Moss Rd. Orlando, Florida 32807 TWX: 810-853-3115 Phone: 305-678-6900



813
magnet
sorter

In the situation where the north or south pole of the magnet may be presented to the probe, use a zero center model gaussmeter. Also add an additional set point relay to actuate on negative outputs.

The easiest solution to magnet sorting and testing problems is to use the Bell 813 Magnet Sorter. It is designed to sort and test magnets. The unit consists of a high accuracy gaussmeter and set points with visual indicators for two or three level sorting. Connect the appropriate probe to the front panel and required audio alarms to the contact closure outputs. The 813 also provides a 1 V dc fs signal accurately proportional to magnetic flux density. Request specification sheet number 60681 for detailed information on the model 813.

(6/75)

Subject: MEASUREMENT OF HIGH LEVEL BUS CURRENTS BY MEANS OF A GAUSSMETER

Introduction

Any conductor carrying a current has an associated magnetic field around it whose magnitude is proportional to the current. A Hall-effect probe, placed adjacent to a conductor as shown on page 2, senses the magnetic field flux density which can be expressed as $B = 2 \times I \div r$ (flux density B in gauss, current I in amperes, and distance r to conductor in millimeters). Example: At 200 mm from the center of a bus carrying a current of 10 kA, the flux density is on the order of $2 \times 10{,}000 \div 200 = 100$ G. The field level indicated on the gaussmeter is therefore a measure for the bus current.

Advantages

Small size and light weight of the probe facilitate its installation near the bus. Calibration can be easily performed by adjusting its distance to the bus. There is no electrical contact with the bus and no voltage drop and power loss as occurs in a shunt. The problem of mounting a bulky magnetic core sensor around the bus and its inherent hysteresis and saturation effects are avoided. Various probe and gaussmeter combinations offer a wide choice of current ranges and accuracies.

Precautions

To achieve highest possible accuracy, the probe must be placed in an area near the center of a straight bus section that is at least one (1) meter long. This area must be free from moving and stationary magnetic materials and from other high current carrying conductors. If the bus and its own return run closely parallel, the probe should be positioned in between the two buses. After initial calibration, the probe must be rigidly mounted to avoid changes in its position with respect to the bus. In case of high voltages, a grounded electrostatic shield between bus and probe is recommended.

Recommended Probe-Gaussmeter Combinations

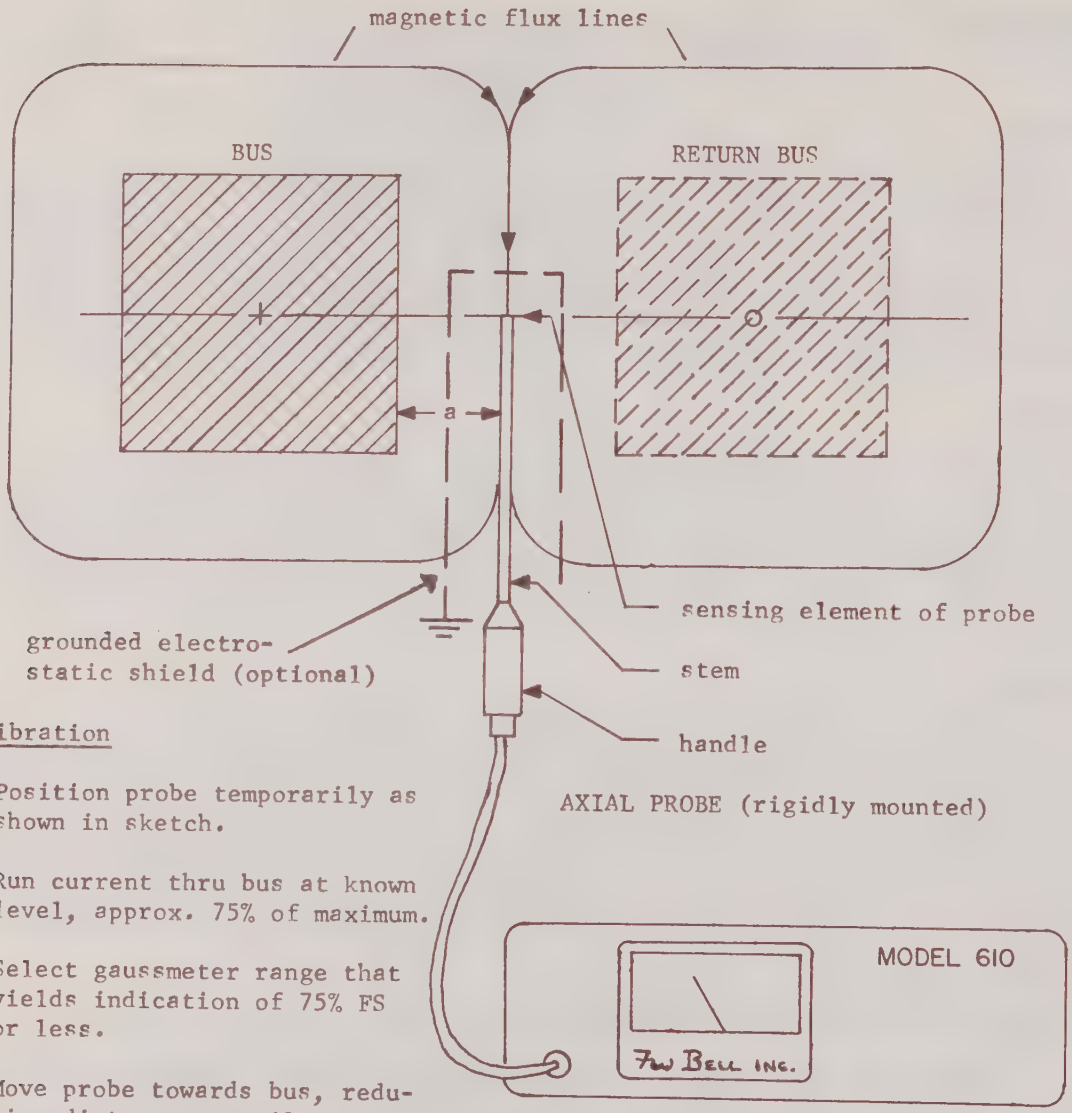
Probe *	Gaussmeter	Power Supply	Lowest FS Ranges (with listed probes)	External Output	Accuracy
PAG3-2504	600 ----	int. battery	100 G and 300 G	0-1 V	4% FS
PAG3-2504	600A ---	115/230 V ac	100 G and 300 G	0-1 V	4% FS
HAK1-2502	610 or	115/230 V ac or	10 G (610)	0-100 mV	0.5% FS
HAK1-2508	615	optional batt.	100 G (615)		

Note: * Or the comparable transverse probe models.

The external output voltage is identical in frequency (consult the gaussmeter brochures for frequency response) and proportional in amplitude to the measured current; it can be used for indicating, recording or control purposes. Other gaussmeters and probes can provide better accuracy. Consult the probe and gaussmeter brochures for detailed specifications, pricing and available options such as probe extension cables, rack mounting, higher output voltages, digital read-out, incremental read-out (zero suppression), etc.

6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

NON-CONTACT MEASURING SYSTEM FOR HIGH LEVEL BUS CURRENTS



Calibration

1. Position probe temporarily as shown in sketch.
2. Run current thru bus at known level, approx. 75% of maximum.
3. Select gaussmeter range that yields indication of 75% FS or less.
4. Move probe towards bus, reducing distance a until gaussmeter indication is approx. 75% FS.
5. Secure probe rigidly in place by means of suitable bracket around handle.
6. Adjust gaussmeter calibration control to obtain exact decimal relation between current level and scale indication.
7. Tag calibrated gaussmeter range with full scale current level.

Additional Application Assistance

Will be provided upon receipt of detailed bus current measuring requirements.

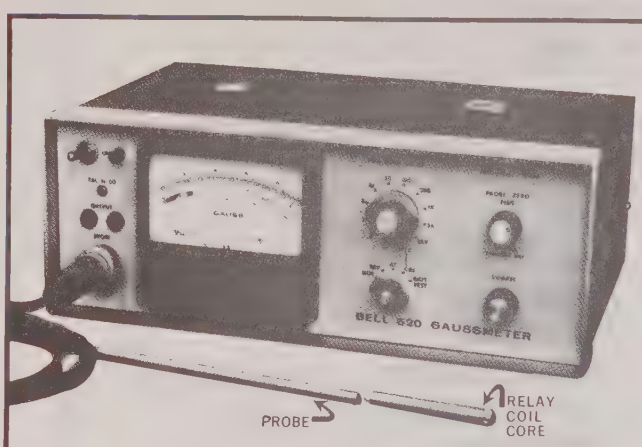
F.W. BELL

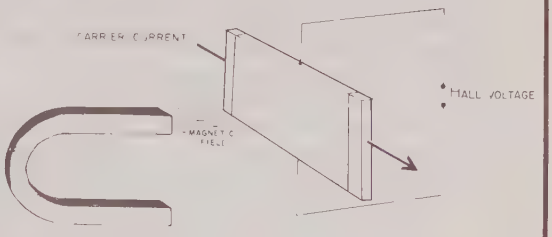
APPLICATION BULLETIN

Subject: Probing For Residual Magnetism Improves Relay Operation

No. 102-G

by John Bosacki, Development Engineer, Western Electric Corp., Chicago, Ill.





Gaussmeter (left) with a Hall effect device in the probe measures the density of a magnetic field. If a current carrying conductor is placed in a magnetic field, voltage will develop across opposite edges of the conductor; the Hall effect is illustrated in the diagram.

Some iron alloy always is used in relay construction. If magnetized above a certain flux density, a magnetic alloy will remain slightly magnetic (residual flux) after the existing field is removed. In other words, some of the magnetism required to make a relay function can be retained in the ferrous components when the current is off so that, in a sense, they become weak permanent magnets — too weak to pick up paper clips or attract iron filings but strong enough to deflect a compass needle.

Side effects from unwanted magnetic characteristics become most apparent in the final phase of relay manufacture — the relay adjustment stage. After considerable effort has gone into blanking, machining, plating, and assembly operations, undesirable magnetic properties in one or more of the subassemblies can manifest their power by overriding built-in compensating devices such as air gaps and non-freezing discs or by making relay adjustment more difficult. In relays with critical timing requirements, the shading of mechanical adjustments to the threshold of measurement may not compensate sufficiently to control the release time response; then, relay parts must be changed. This necessitates extensive readjustment and does not guarantee success.

The best way to avoid such haphazard procedures would be to find some means of positively identifying parts that are magnetically deficient. Even if there is no method of absolutely identifying a part as magnetically unsound, it is possible to tabulate data on the magnetic response of relay parts so that a deficient part can be recognized. The production value of such data is obvious.

Measuring Residual Flux Density

Residual flux density has a theoretical range that stretches from the point where it adversely affects product performance to the point where it is practically non-existent. Between these two extremes the maximum residual flux density that can be tolerated by individual relay parts requires definition by measurement.

One method is to submit a few suspect parts for laboratory analysis. Although this provides precise, conclusive results, time involved, cost of utilizing sophisticated laboratory equipment, and the problems of parts segregation are not compatible with mass production procedures.

Another method is the use of a gaussmeter with a Hall effect device to measure the flux density of a magnetic field. A direct reading of the level of residual flux can be made by touching a surface of a part with a probe from the gaussmeter.

The iron parts to be tested are saturated magnetically by touching any convenient surface with a strong bar or horseshoe magnet. Partial assemblies or completed relays can be magnetized by energizing the relay coil.

The gaussmeter* used to study the production value of this latter method generates a current and applies it to the tip of a standard probe** in which a thin, waferlike semiconductor that functions as a Hall effect generator is embedded.

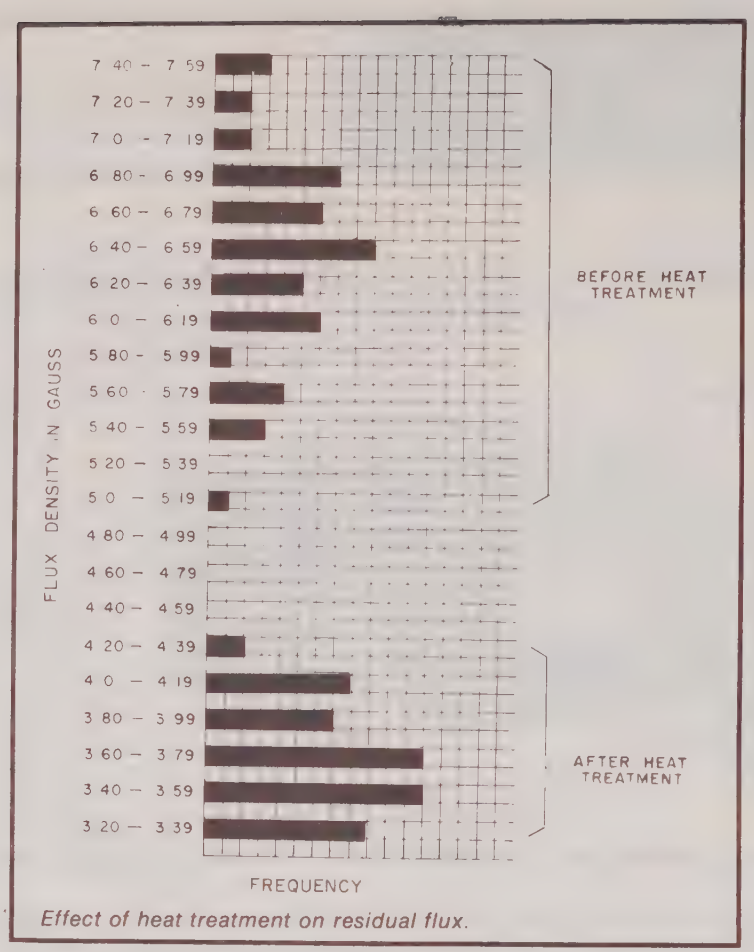
If a current carrying conductor is placed in a magnetic field, a voltage

---

**Model No. HAG4-2508 axial type probe by F. W. Bell Inc.

will develop across opposite edges of the conductor. This, in a few words, is the Hall effect. It depends upon the deflection of charged particles moving in a magnetic field. The Lorentz force is in a direction mutually perpendicular to the path of the current flow and the direction of the magnetic field. Voltage output is the result of current and magnetic field strength. If either is zero, voltage is zero.

The Hall element in the gaussmeter is fed by a locally generated, current regulated excitation signal which causes input chopping action. A field modulated a-c carrier output voltage is produced when the Hall element is placed in a magnetic field. Hall output voltage and calibration output from the probe are applied to the summing circuit along with zero control, suppression controls, and feedback range attenuator outputs. The synchronous filter amplifier and feedback attenuator combination provide amplification. Then, the amplified carrier is restored to a field proportional voltage without loss of polarity (field direction) information by a synchronous demodulator. If the field is time varying, demodulated output will be instantaneously proportional to the field waveform up to 400 Hz.



Effect of heat treatment on residual flux.

Effect of Heat Treatment On Residual Magnetism

The effect of a heat treating operation designed to enhance the magnetic characteristics of an iron core initially having a higher level of remanence than desired was evaluated with the gaussmeter and probe. This higher level of remanence may have been inherent in the raw material or introduced through previous manufacturing processes. The coil cores were magnetized by touching the end of each 3-inch rod shaped piece with a horseshoe magnet. Measurements were made by centering the probe of the gaussmeter on the magnetized end diameter. Parts were magnetized with a relatively strong magnet (850 gauss at the pole) just prior to measurement, yet the magnetic flux retained by the components was very low (less than 8 gauss). In this instance, the reduction of the average level and spread of the measurements after heat treating provides a distinct separation between the before and after distribution and clearly confirms the effectiveness of the heat treating operation. Such data are valuable because they can be compared with similar information on suspected magnetically deficient material.

With soft iron components, retained magnetic flux is very low, and variations in procedure will introduce gross errors in measurement of the static field. Touching the edge of a part with a bar magnet will yield a different reading than dragging the magnet across the length of the part. Care should be taken to magnetize the parts the same way, every time, if reliable results are to be obtained. The type of magnet employed and the polarity induced are factors that will influence the values of the readings obtained, but careful adherence to uniform methods will preclude unwanted variations. In low level applications, it may be necessary to shield parts from stray magnetic fields. The effect of the earth's magnetic field can be overcome by orienting the part and probe in a plane perpendicular to the earth's field. Jarring of parts in the interim between magnetization and measurement should be avoided. The configuration of the part and the points of measurement are factors that will influence measurement. It was found that measurements made at the end of parts or at identifiable protuberances provided the most repeatable data. It is advisable to maintain recorded data on the degree and point of saturation, part orientation, point of measurement, and values of measurement.

Summary

With this quick means of measurement of the residual flux density and the accumulation of data that establishes the desired parameters of the various parts, it becomes a simple matter to magnetize and measure questionable material and determine the extent that it will affect product performance. Sampling suspect lots by this method can lead to intelligent decisions on the disposition of the product. This procedure discriminates well enough to sort magnetically deficient product from mixed material and has been used effectively in determining the economic advantage of using, salvaging, or scrapping suspect material.

Reprinted by permission from the May, 1975 issue of *Insulation/Circuits*. Copyright 1975. Lake Publishing Corporation, 700 Peterson Road, Libertyville, Illinois 60048 U. S. A.

F.W. BELL

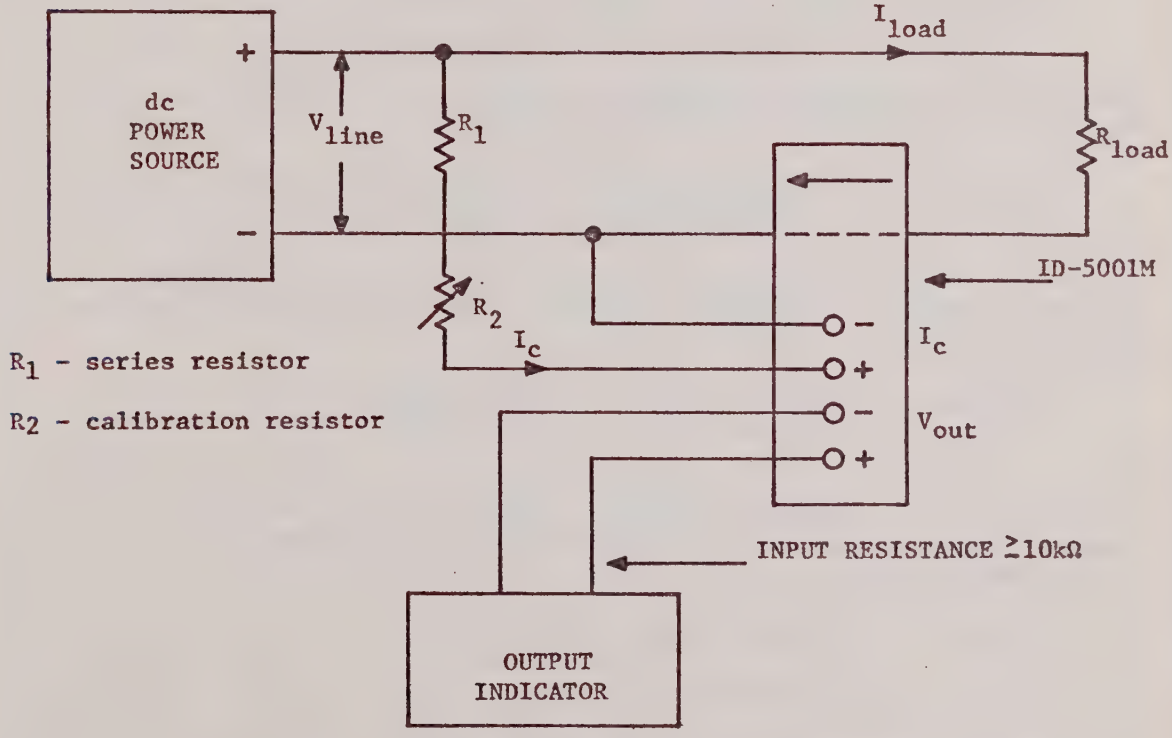
APPLICATION BULLETIN

Subject: MEASUREMENT OF dc POWER USING CURRENT SENSOR ID-5001M **No.** 100 I

The output voltage of current sensor Model ID-5001M is accurately proportional to the product of the measured current and the excitation current. This multiplying feature allows the ID-5001M to be used as a dc power measuring device.

The diagram below illustrates a typical schematic for such an application. The load current is sensed in the conventional manner by running the dc power line thru the sensor window. The excitation current, Ic, is derived from the dc line voltage thru dropping resistors R_1 and R_2, and is therefore proportional to the dc line voltage. As a result,

$$V_{out} = k \times V_{line} \times I_{load} = kP$$



CAUTION: The output indicator circuit is NOT isolated from the power circuit! The output circuit is connected to the dc power circuit through the Hall generator in the ID-5001M sensor. If the load is at a high potential above ground, isolation may be required between the sensor output and the indicating device to prevent personal injury. For proper operation either the dc power circuit or the output indicator, but not both, may be grounded.

-over-

6120 Hanging Moss Rd. | Orlando, Florida 32807 | TWX: 810-853-3115 | Phone: 305-678-6900

It is usually desireable to obtain the highest possible full scale output that is conveniently related to the maximum dc power level. For example, a full scale output of 50 mV at 50 kW (1 mV/kW) or 100 mV at 200 kW (0.5 mV/kW). To achieve this, suitable values of the dropping resistor R_1 and R_2 must be determined, observing that the maximum permissable excitation current (Ic) is 40 mA and taking into account the sensor's calibrated output sensitivity (between the limits of 0.25 mV/A and 0.45 mV/A, as shown on the sensor label). This can be done with the following 5-step procedure. Examples are given for a dc power system operating at line voltage = 500V, maximum load current = 200A, and a current sensor ID-5001M with a calibrated output sensitivity of 0.300 mV/A at Ic=20mA (nominal excitation current).

1. Determine the maximum possible output of the sensor at maximum load current.

Example		
	Maximum load current	200A
	Calibrated sensor sensitivity (see label)	0.300mA/A
	Nominal output at Ic=20mA: 200 x 0.300 =	60mV
	Maximum output at Ic=40mA: (40/20) x 60 =	120mV

2. Determine the maximum system power and select a convenient full scale sensor output which does not exceed the maximum output calculated in Step 1.

Example		
	Maximum system power: 500V x 200A =	100kW
	Convenient full scale output at 1 mV/kW =	100mV

3. Determine the excitation current, Ic, required for the full scale output that was determined in Step 2.

Example		
	Ic for 120 mV output at 200 A (from Step 1):	40mA
	Ic for 100 mV output at 200 A: (100/120) x 40 =	33.4mA

4. Determine the value and power dissipation of the dropping resistance ($R_1 + R_2$) needed to derive the excitation current, calculated in Step 3, from the maximum system voltage.

Example		
	Dropping resistance = V/Ic = 500V / 33.4mA =	15kΩ
	Power dissipation = V x Ic = 500V x 0.0334A =	16.5W
	=	1.1W/kΩ

5. Based on the data obtained in Step 4, select suitable commercial values for R_1 and R_2 with adequate power rating and allowing a calibration control range of approximately ±15%.

Example		
	R_1, fixed, approx. 85% of 15 kΩ =	12 kΩ. 25 W
	R_2, adjustable, approx. 2 x 15% of 15 kΩ =	5 kΩ. 12 W

Complete the measuring circuit, operate the dc power system with a known power, and adjust calibration resistor R_2 until the desired corresponding output is obtained.

The semiconductor systems described herein are intended only to illustrate typical applications. The information is believed reliable; however, no responsibility is assumed for inaccuracies.

Subject: COMPENSATION FOR TEMPERATURE VARIATIONS ON HALL EFFECT GAUSSMETER PROBES

No. G100

All Hall effect probes exhibit temperature drifts; zero drift and sensitivity drift.

Zero drift may be ignored at high field levels but should be considered for low field measurements. Be aware that with a 1X probe, the zero drift and sensitivity drifts are approximately equal in magnitude at 200 gauss (20 millitesla). Below 200 gauss, the zero drift can be substantially more than the sensitivity drift. For 10X probes, the zero drift can become the dominant factor below 2000 gauss (.2 tesla). The specification sheets give only a maximum possible magnitude. The zero change may be positive or negative and its value varies drastically from probe to probe. Therefore, compensation is difficult without a curve of zero drift, (available as an option with certain probe models).

Sensitivity drifts of 1X probes are relatively consistent from probe to probe and reasonably accurate correction calculations can be made using the following formula:

$$B_a = B_g \left[1 + (tpm - tpc) \frac{tc}{100} \right]$$

where:

B_a = actual value of the field being measured (unknown)

B_g = the value of the field as indicated by the gaussmeter

tpm = the temperature of the probe at the time of measurement, in °C

tpc = temperature of the probe at the time of calibration, in C (25 C when using internal CAL)

tc = temperature coefficient of the probe in % per °C (listed in the probe literature)

This will correct the gaussmeter "B_g" to give the actual field "B_a". Notice that tc is a negative number, and the sign must be carried into the formula. For high accuracy compensation, use sensitivity drift curves, available as an option from F.W. Bell, Inc.

If the probe temperature is not known, rapid thermal variations are expected or wide field ranges are to be measured, use the 10X, low temperature coefficient probes. Below 30 gauss (3 millitesla), the 1X probes may offer greater stability than 10X probes. Following these rules will allow high resolution measurements and solid outputs for system control. But remember, the only way to be sure of absolute field values at various temperatures is to use a calibration curve.

(3/75)

NOTE: 1X probes are standard sensitivity and 10X probes are one-tenth sensitivity.

www.manualsplus.com
1025521